I couldn't really read their expressions. I took off the glasses when it was time for dinner, and when I was carrying my dishes my head felt funny for a moment or two and I felt dizzy as if I were seasick. But after four or five minutes, I soon recovered," he said.

The Day's Impressions:

The degree of fatigue lessened compared to Day I. As for watching T.V., it was interesting, but still I soon got tired. People and plants didn't look like they were alive, seemed unreal, and looked flat and unchanging. But music that I listened to on a tape recorder sounded more lively than usual.

M.T.: 'Today, the feelings of strangeness were somewhat decreased compared to Day I. However, when I looked at people or physical objects, I could make out the shape but I could not make smaller distinctions such as whether they were hard or soft. In addition, I could not make out the small changes in people's expressions at all. It wasn't an extraordinary physical obstacle, but when I took off the glasses to eat, my head shook up and down and felt heavy for awhile and I felt dizzy. After about ten minutes I put the glasses back on and the feelings went away," he said.

The Day's Impressions:

'Sight works for the body to prepare it for making ordinary movements, doesn't it? Also, when not using these glasses, sight has a preparatory function and also works to decrease stress in dealing with physical objects. When wearing the prism glasses,

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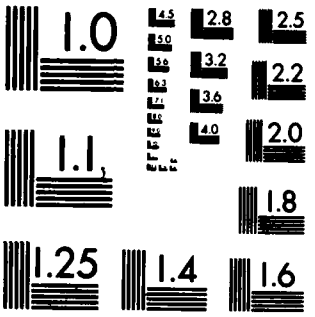

not only do you not receive the necessary information, but stress from the outside world increases, doesn't it?"

(3) Day 3

The subjects became more active and didn't lie down in the ward; they strolled frequently about the hospital. They said, "I'm getting used to an upside down world," and "I have become comparatively able to handle my personal property and so forth that is in the room." Because they also said, "I can decipher my medical textbooks a little," we administered a transcription test with short and long sentences. It took them quite a bit of time, but it was possible for them to do it. The instability in the visual field decreased quite a bit, but one subject stated, "When I'm talking with a friend, it's like seeing the friend on video and talking to him or her on the phone; things still don't seem real."

E.U.: "I have gradually become used to the upside down world. Even when I did the various tests, I wasn't very tense. I had the will to try and do them. But I felt estranged from the outside world. I began to feel like talking with the other patients in the ward, but the feeling of strangeness that friends and the other patients were in another world continued. When I removed the glasses at dinner time, I began to feel quite dizzy. This continued for about ten minutes and was especially obvious when I nodded my head up and down. It went away when I put the glasses back on. The world is all standing upside down, but it's gotten so that it doesn't really bother me."

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(2)

FTD-ID(RS)T-1827-82

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FOREIGN TECHNOLOGY DIVISION

KYUSHU NEURO PSYCHIATRY

(Selected Articles)

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The Day's Impressions:

"Concerning human beings' superiority to animals, humans are quicker to adapt to a changing environment, and they adapt well."

M.T.: "Today I could read even the fine print in the newspaper. I made quite a bit of progress in walking. However, it is confusing when I enter a place where there are many people. The reason is perhaps that I still can't judge distances very well. Things and people that are close seem large and ones that are in the distance seem small. The world, after all, is upside down, and I still don't see things correctly." But he stated that he is not strongly conscious of the obstacle to his vision.

The Day's Impressions:

"I took a test of what is left and right in a picture. After the test when I asked the other patients, I found out that we had guessed left and right incorrectly. The world still lacks a feeling of reality and I feel dizzy when I remove the glasses."

(4) Day 4

Both of the subjects began to say, "We feel that the rhythm of our lives has returned to what it was like before we put on the glasses." They became more active than on the previous day and went out to the classroom and the laboratory and were able to read their medical texts. They began to say such things as, "I still feel that the outisde world lacks reality. But I have been able to rely on my vision while moving." /260

EDITED TRANSLATION

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PREPARED BY:

TRANSLATION DIVISION
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WP-AFB, OHIO.

E.U.: "I feel that we have passed the peak of this thing. Yesterday there were many times when vision with the glasses was a hinderance to action, but today I find that I am not particularly conscious of that. The world is still upside down but I realize that I don't particularly notice that it is upside down. I still don't feel that things are alive. But when I look at something and think that I'll pick it up, I'm able to go right to the place where it is."
The Day's Impressions: "The world is still upside down. But compared to Day 3, I was able to observe more small details. I was able to grasp the door knob quickly, but handling things like putting tooth paste on a tooth brush were still difficult. I still can't compensate very well visually for those aberrations caused by wearing the glasses."

M.T.: "I became able to accomplish all physical activities better than yesterday. When other people began to talk to me, it became natural for me to turn my whole head in that person's direction because my field of vision was narrow. Usually, when talking with someone or when following a person with one's eyes, you just keep them in your line of sight by moving your eyes. But when you put on these glasses, the visual field is narrow, so soon the person will disappear from sight. Sometimes I don't move my head, or I turn my head too far, or move it excessively, and the field of vision shakes. But today I'm able to do that kind of thing naturally. I learned to turn together with the movement of my objective to get it in my field of vision. /260

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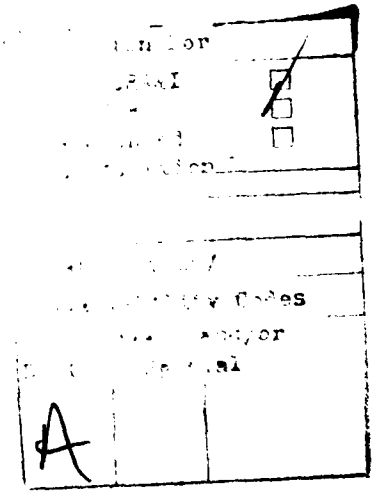

The outside world was inverted and I didn't see it upright, but I could see scenes and changes in people's expressions in detail. But it was like seeing the world through a thick glass door, and when I looked at a person it was like seeing them reflected in a mirror. The feeling of dizziness when I removed the glasses was gradually getting stronger.

The Day's Impressions:

"I think that we passed the day comfortably without tension. We were able to finish such activities as transcribing sentences fairly quickly."

(5) Day 5

"We were confused by activities that required careful thought, but for exercise or walking, they were close to our normal state without wearing glasses. But the world was all inverted and we couldn't see anything correctly. But around noon, when walking down a hallway that looked symmetrical, when I looked up at the ceiling I thought for an instant that I was seeing things right side up. But when I looked carefully, it was still reversed after all. Perception of distances still had not completely returned to normal. I thought that people and scenes looked as though reflected in a mirror and seemed unreal," one of the subjects stated. One of the researchers asked, "How would it be if you wore the glasses for twenty years?" "If the field of vision were wider, I don't think it would seem inconvenient," they answered.

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GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

E.U.: "I think that I've pretty much become accustomed to the inverted world. But things that should fall according to the natural laws of gravity accelerate and rise instead. And I feel uneasy about things like tabacco smoke "rising" downwards."

The Day's Impressions:

"The times when I am able to move without being conscious that I am wearing the glasses are gradually increasing."

M.T.: "The outside world was all inverted, but I didn't feel that there were really any obstacles to movement. Perhaps this shows that it doesn't really matter if things are seen upside down. If the concepts that I create in my own mind about the outside world are not contradicted by other people, then I think that whether the image is right side up or upside down is not significant."

The Day's Impressions:

"There was no obstacle to normal activity. Just when I made precise movements my vision was a hinderance. Also, the dizziness when I take off the glasses seems to be increasing."

(6) Day 6

Except that they were using the glasses, the subjects' activities were for the most part close to normal. "In the morning I did calisthenics to the radio with the other patients and in the afternoon played ping pong. But because the ball moves quickly, it would soon go out of my field of vision. When I swung the paddle, I often swung above the ball and missed.

EXPERIMENTAL STUDY OF INVERTED VISUAL FIELD BY INVERTING PRISMS

by

Hideaki Ninomiya, Masahiro Fujihara,
Terutika Ikeda

If I could rally two or three times, usually that was the best I could do. After all, the world is upside down, and I was not able to see things correctly."

E.U.: "I could move more skillfully than yesterday. From the six days' experiences, maybe I can suggest that "seeing correctly" means a situation in which one can move skillfully and naturally without being aware that things are upside down.

When doing something like eating with the glasses off, there is a feeling of dizziness and the world doesn't seem real. But this feeling of unreality is lessening every day. The oscillation in the visual field has also decreased."

The Day's Impressions:

"I still can't really tell distances or if things are solid or not. Even if I get used to the world upside down, I think that to be able to grasp these differences correctly will come very slowly."

M.T.: "Today even though there were tests, they were not difficult. When transcribing sentences, I was able to write in my usual style. The world was upside down but this was not troublesome."

The Day's Impressions:

"I became able to live looking at the world upside down without being conscious of it. But when I was asked if I saw things right side up, I had to answer, 'The image is upside down.' When I did something like scoop up ice from a plate with a spoon, I was hampered by my vision. If I were to go into a place where

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Introduction

Stratton (1896,1897)[20)21)22)] conducted research on the thesis that in order to see the outside world correctly, inversion of the retina image is necessary. His work was followed by many other studies.[3)5)6)8)9)10)13)18)19)] In this research, when inversing prisms are used, after several days the inverted visual field is sporadic and, following the "all-or-none law", vision generally perceives objects correctly (upright). There are two opposing theories: the theory that this change in visual perception occurs,[10)13)21)22)] and new visuo-motor studies that show that there is adaptation to the stimulus from the outside world but not a change in perception.[3)5)6)17)23)] There is not yet agreement on this subject. Concerning the changes that occurred in the cases where inverting prisms were used, the authors simultaneously observed the subjects' behavior, recorded experimental change, and did various tests such as activity tests, psychological tests, and polygraph tests. In this report, first we will focus on the subjects' behavioral changes and compare the results with previous experiments.

Objectives and Methods

1. Subjects

The subjects were two healthy students at the Miyazaki Medical College. These subjects had an interest in the experiment and participated eagerly; they were paid.

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* Numbers in the margin indicate pagination in the foreign text.

there was a complicated arrangement of chairs, I suppose I would be confused."

(7) Day 7

The subjects said that for the most part they are accustomed to the upside down world. They can read and write characters and they can smoke cigarettes. "When I think of someplace that I want to go to, I can generally get there without a hitch." They were told to ride a bicycle, and both subjects went back and forth several times over a 50 meter course, successfully made the U-turn, and were able to return to the starting point. They managed it skillfully.

E.U.: "There were various tests, but none of them were difficult. The world remained upside down and it was like seeing through a thin, transparent membrane. The dizziness when we had taken off the glasses today was a great deal stronger. Distance perception was a little better, but oscillation in the visual field continued somewhat."

The Day's Impressions:

"I have become nearly completely accustomed to the upside down world. I feel able to relax."

M.T.: "Day 7 was the final day of the experiment. But, after all, everything looked upside down. If we had to live with this state of affairs, I have come to believe that it would be possible."

The Day's Impressions:

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Subject 1: E.U., age 23, male. His body type is a combination of the mesomorphic and endomorphic types and his I.Q. (WAIS) is 129. He is nearsighted in both eyes (0.1 corrected to 1.2). He is left-handed and when he was a child between the ages of four and six he was forced to write and use chopsticks with his right hand. Now he writes with the right hand, but uses his left hand to do such things as cut paper or draw a line. In personality, he is sincere and quiet.

Subject 2: M.T., age 23, male. Mesomorphic body type. I.Q. (WAIS) 134. Nearsighted, right eye 0.5 (corrected to 1.2), left eye 0.4 (corrected to 1.2). In personality, quiet and steady. He is right-handed.

2. Research Procedure

This experiment was mainly conducted in a ward of the psychology department of the hospital connected with the Miyazaki University Medical School. The subjects entered the hospital the day before they began wearing the inversing prisms, and psychological tests, polygraph tests, and so forth were conducted. They went to bed at nine o'clock that evening and they put on the inversing prism glasses when they got up at seven the next morning.

The times when they did not wear the glasses were (1) while sleeping, (2) for 20 minutes while bathing, (3) for 30 minutes before and after meals, and (4) for 12 minutes while taking the polygraph test. In the ward, they passed the time in the same manner as the other patients. The experiment was carried

"I was able to handle the various tests comfortably. The world still doesn't seem alive; it seems unreal. There is also oscillation in the visual field, today dizziness is stronger, and it stops when I put the glasses on."

Considerations

Concerning distortion of vision, adaptation, and the after-image effect, according to experiments by Helmholz and others[4] distortion of vision caused by using a prism is known to decrease within a comparatively short period of time. Based on this study, Stratton[21][22] found that the world is seen right side up in spite of the fact that the image on the retina is upside down. And, wearing the prism glasses, the world is reversed and the image on the retina is actually right side up. The result of wearing the prisms is first that the world is seen upside down and vision predominance disappears. The person begins to rely on the evidence of the other senses, that is, hearing and touch, and proprioceptive sensation becomes predominant. The senses are in disorder, and the subjects are confused. From the second day of Stratton's experiment, the world looked right side up and, following the all-or-none law, what had been seen upside down until then was intermittently seen correctly. Both the frequency and the duration increased; there was no time when they saw the image both ways.

This kind of right side up vision increased with the passage of time during the experiment. The feeling that the world was

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out as shown in Table I. Every evening from six p.m., one of the authors listened to the subjects' accounts of their experiences and activities during the day. Also, the subjects were instructed to write down each day's experiences on cards every night before sleeping.

The special glasses used in this experiment are called inversing prisms and are made by Takeikiki Kogyo, Inc. Two total reflection prisms that are 4 cm in length are attached to a metal frame with a 2cm space between them, this weighs 340 gm. The glasses are fastened to the head with an elastic band. The visual field for both eyes is 40° in the horizontal direction and 27° vertical and 45° on a diagonal line, the transparency is 75%. The visual field is reversed 180° and left and right are not reversed (Figure I). The size of the image that can be seen is about the same as without the glasses. Also, when gazing steadily to the front, the line of vision drops a little, and when looking directly at the horizon, the wearer has to drop his face a little bit.

The two subjects' beds were placed in a room (13.16 m^2 floor area) that was close to the nurses station. The subjects were allowed to read the magazines that they normally read and also to bring a tape recorder and listen to music.

In this experiment it was easy to observe the subjects who were admitted to the hospital. We were also concerned that, except for wearing the glasses, the subjects could pretty much lead a normal life.

strange and unusual began to disappear and it was reported that the subjects became able to do activities that required dexterity such as riding a bike.

On the other hand, there is another theory about these results that there was no complete return to normal vision but that the subjects adapted over a period of time by relying on stimuli from the outside world and thus gradually became adjusted. As yet, there is no agreed upon interpretation.

In the literature, the research done with inversing prisms by Stratton [17)22)23)] and, in our own country, Makino[13)14)15)] is of value as pioneering research in the field. But these studies were characterized by the fact that the researcher was either the subject in the experiment or was one of the subjects. Also, the experimental results were limited to their records of their impressions. As for their research methods, first, the person who wrote the study is the one who wore the glasses and experienced the reality of the inverted world for a long period of time. There were advantages to this in that it was easy for the researcher who wore the glasses himself to understand the other subjects' reports of their experiences. However, this makes it all the more a subjective experience of the researcher's and there is a danger that the researcher will misinterpret the reports of other subjects. There is also a possibility that small points such as differences in adaptation to the inverted visual field that originate in differences in individual experiences

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Table I: Subjects' Daily Schedule

previous day	day one	day two	day three	day four	day five	day six	day seven
	get up (7:00)	"	"	"	"	"	"
	breakfast (7:30)	"	"	"	"	"	"
	cutting circles pegboard Kraepelin	cutting circles copying exercises	radio exercises cutting circles copying exercises	radio exercises cutting circles copying exercises	radio exercises cutting circles copying exercises	radio exercises cutting circles copying exercises	radio exercises cutting circles copying sent. Rorschach MAS Bender Gestalt
lunch(12:00)	"	"	"	"	"	"	"
Rorschach Kraepelin Bender Gestalt CMI, MAS, SCT pegboard polygraph	polygraph	Bender Gestalt polygraph	Kraepelin MAS polygraph gravity scale pegboard polygraph	Bender Gestalt gravity scale	Kraepelin pegboard gravity sc. sketching polygraph	Bender Ges. gravity sc. ping pong polygraph	Kraepelin pegboard gravity scale bicycle sketching polygraph
dinner(5:30)	"	"	"	"	"	"	"
	write report	"	"	"	"	"	"
bed (9:00)	"	"	"	"	"	"	end of experiment (8:00)

This experiment with inversing prism glasses was conducted from March 26,1980 to Wednesday, April 2. On March 25 we did several tests with the device shown in figure 1 that restricts the field of vision as much as the inverted prism glasses would. The subjects then wore the inversing prism glasses from 7a.m. March 26 to 8p.m. April 2, tests were conducted as shown in the chart. When the subjects were not taking tests we told them to do things like watch t.v., walk, read, etc. The glasses were put on when the subjects got up and taken off when they went to bed. They were also taken off for meals, baths, and to take some of the tests.

and personality may be overlooked.

Furthermore, if the subjects are of different ages, differences in adapting to the inverted visual field also can be expected. In the research mentioned above, there are doubts about whether or not the important part of adaptation to the inverted visual field was correctly interpreted or not. Concerning this point, one of the authors plans to publish a separate study based on the results of the various psychological tests.[7)]

In view of the above points, the authors decided to use the research methods that they did in this study. That is, the subjects and the researchers were not the same persons, the subjects were admitted to a ward of the hospital and wore the glasses there so that they could be easily observed, and, in this way, information was obtained by both observation and report.

The results obtained by the authors are very different from those reported by Stratton and Makino. For example, according to Stratton's research, adaptation to the inverted visual field was comparatively fast. His subjects even saw the visual field right side up on the first day of his experiment. But ordinarily the visual field was inverted and disturbed. On Day 2, they became able to see themselves right side up. Moreover, on Day 3, the disturbance in the visual field decreased and they became aware of movement of their own bodies not just when it could be seen in the visual field. On Day 4, they saw the visual field correctly more often, especially when they were moving they felt

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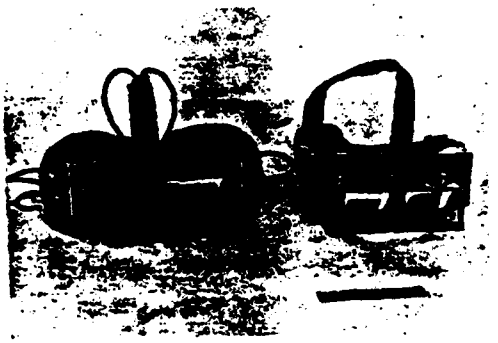

Figure 1: The prism glasses on shown on the right. On the left is the device used to limit the field of vision in the same way as the prism glasses do.

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that things were right side up and realistic. On Day 8, it was reported that there was agreement between vision and hearing and vision and touch. They were able to turn their heads in the direction of a crackling fire, for example, and the pencil that the subject took in his hand agreed with the one that he saw in his field of vision.

Moreover, according to Makino, his research was different from Stratton's. But concerning "right side up vision" and "right side up," he regulated more clearly that Stratton did the progress from inverted to right side up that is the all-or-none law [13)14)15)] and saw no middle ground. The frequency of seeing right side up and the duration of "correctness" increased with time, he found.

Stratton, as a basis for judging whether vision was inverted or not, had to turn to evidence from senses other than vision. As for correct vision, it occurred in the instances where visual and tactile evidence or visual evidence and body sensation were in agreement. Furthermore, he stated that body orientation had a great deal to do with correct or inverted vision. Makino is also seeking evidence that right side up vision is related to physical orientation.[14)] There is no agreed upon answer on this point as yet.

Evert[3)] did an experiment using the inversing prism for both eyes that was used by the authors. Two weeks after the experiment

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For the experiment, various types of experiments, as shown in Table I, psychological tests, polygraph tests, sketching tests, and so forth, were done. But in this section, first our objective is to compare the changes that occurred during a one week period wearing the glasses with previous research. The results of the various tests will be presented in later section.

Results

First, there is a summary of each day' ctivities, actions, and experiences. This is followed by a r of each day's experiences that the subjects made to the researchers every evening, and finally, the subjects' impressions that were recorded every night before they slept.

(1) The First Day

At seven a.m. on March 27,1980, the two subjects put on the glasses under the supervision of the researchers. Afterwards, the subjects were fairly calm. If they had free time they lay down on their beds and listened to music. But when they tried to look at the medical textbooks that they had brought, they said such things as, "Because the letters are upside down, I can't read at all." or,"I can make out the large print in weekly magazines and newspapers or in headlines. When a book is held upside down, the characters are reversed. When I look at this from the back side of the page, because it look right side up, it is easy to read. But using this method, when there is writing on the back side of the page I can't make it out very well and

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began the subjects performed vitually all activities with the glasses on and they had adapted to the view that they saw of the outside world, but they reported that the world remained upside down. Kohler[10] found that adaptation to activity in the outside world could be seen fairly soon, and that even though the subjects adapted almost completely they saw the world upside down and not correctly right side up. In this experiment, the authors conducted various tests focused on changes over time in the physical sensations[12] such as touch, the sense of pain, motor awareness, and the senses such as vision and hearing. At the same time we observed changes in activity and kept records of the subjects' impressions. We analyzed the data and found that adaptation is slower for fine motor skills that require a visual guide than for activities that comparatively do not require a visual guide.[1)2)11)] We think that these results can be used as an index of changes in perception that are related to the inverted visual field and the degree of adaptation to the world when seen upside down.

On the other hand, there is criticism of our way of conducting the experiment in that we used change in movement and activity as an indicator of change in vision (Makino, 1976[14]). But the objective of this paper was to present the subjects' impressions and the changes in their behavior. Later, in a separate paper the research will be presented in more detail.

The authors feel that, inspite of the fact that neither subject

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the characters are hard to read. It takes time and I get tired." In addition, the field of vision is narrow, and "when I look at my feet, my body looks like it's across from me. Even when I try to put on my shoes, because my hands and feet don't go where I think that they will, it takes time. When I try to walk down the hall, I can see the ceiling. It's like I'm walking on the ceiling. I can see the surface of the floor above me. If I don't walk being careful of what I see above me, I'll bump into something in the hallway. I can't help stumbling. My field of vision is narrow and because I can't really see where I'm going, when I go up and down stairs, I have to put my hand on the wall or walk while holding onto the railing, and if I don't learn how many steps there are, I'm likely to miss the last step." But he said, "when I go to the lavatory, I put my hand on the wall of the lavatory and am able to use the toilet by feeling where I am with my hands."

The subjects gave positive responses in their records of their impressions and in the tests such as psychological tests and polygraph tests. At least, for the two subjects, extreme feelings of discomfort, psychological agitation, or physical ill effects were not seen.

E.U.: Throughout the morning, the field of vision was narrow and there was oscillation in the visual field. When I walked, the things that I could see seemed to tremble. Because everything

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saw the world right side up, because of the subjects' activity with an inverted field of vision and their fairly good adaptation, this research comes close to the results obtained by Evert[3)] and Kohler[10)]. That is, they adapted well in their activities, so perhaps we can say that they began to not be aware that the world was upside down. There is a restructuring [1)2)] of body awareness and the corresponding senses including sight. It is thought that this is related to a learning process that connects sight and movement (Katori, 1969[11)]).

The authors' research took place over a period of one week and this was shorter than previous studies that lasted from eight to thirty-seven days. If the research had continued for a longer period of time, the results might have been different, but this is only speculation. The thing to note here, is that while feelings of unease from oscillation in the visual field and feelings of strangeness decreased over time, distance perception, according to the two subjects, was slower to change. For example, oscillation was not seen in a horizontal direction parallel to the reflecting surface of the glasses. This is an optical characteristic of the prism, and it goes away or decreases during the course of the experiment. Stratton[21)22)] recognized this in his experiments when the visual field was reversed using a prism, and it is known to be a characteristic of inverted vision. Also, in contrast, dizziness when the glasses are removed became stronger and ceased when the glasses were put back on. This study suggests that an individual will adapt /263

would shake when I turned my head, things would slip out of my field of vision. When something slipped out of sight, I couldn't follow it very well. When I turned my head, I would turn it too far and the thing that was my objective would not be in my field of vision. When I tried to grasp something with my hand, because the hand would appear from the opposite side, I thought that my physical sensations seemed to be confused. Even to pick up a book takes time. In the afternoon near sunset, I had gotten somewhat used to it. Because letters looked reversed, I could make them out, but it took time.

In addition, if I tried to pick up a pen or pencil that was on the desk, my hand would move too far, or off to the side, and because it took several tries to get it into my hand, it took time. If I looked down to try and put on my slippers, because my own feet would appear from beyond my field of vision, I could not put them on easily. I gave up and put them on the wrong feet. These actions could be done more quickly with the eyes closed by relying on the sense of touch. My vision was constantly disturbed.

Furthermore, I had no real feeling about people or the outside world. I could not read the doctors' or nurses' facial expressions. As for food, it did not seem to taste very good when I was wearing the prism glasses. When I took them off, quickly my surroundings came alive and I felt hungry. When I took off the glasses and shook my head forward and backwards,

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to vision inverted by means of a prism. But these problems are not insignificant and careful consideration is necessary. When we give the results of various tests in a separate paper, these results will be given further consideration.

Summary

In order to do a detailed study of physical adaptation and sensory adaptation, various experiments were conducted on the process of adapting to a world that looked upside down when inversing prism glasses were used. In addition, speculative studies were done and records kept of the subjects' impressions. This paper focused on observations of the subjects' behavior and records of their impressions during the experiment and compared the methods and results with previous studies.

The subjects were two healthy students from the Miyazaki Medical College who spent one week in a ward of the Psychology Department of a hospital connected with the Miyazaki Medical College. They wore the inversing prism glasses, and various tests -- psychological tests and others -- were conducted throughout the one week period of the experiment. Records of impressions and changes in the subjects' behavior were also kept.

First, to look at the process of adaptation, on Day I of this experiment, instability in the visual field was clear, the world seemed to shake, there was a feeling of unreality and an inability to make out characters, although the subjects were able

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I felt that my whole body was moving. But when I shook my head to the left and right, nothing happened, he stated.

The Day's Impressions:

"When I could get the thing that I wanted into my hand, I felt relieved. Because all movements were difficult to accomplish, Day 1 felt very long. Because the T.V. image was reversed, I didn't feel like watching it."

M.T.: Throughtout the morning of Day 1, I often wondered, 'Where am I?' Because the outside world was reversed and the colors of things and scenes seemed dead, they didn't feel alive to me. This continued all day. Also, in the same way as the other subject, the extent of my confusion during the morning was great, but in the afternoon I became somewhat used to the world upside down. Subject 1 and I had for the most part the same kind of experiences trying to read, or put on slippers, or pick up objects. On the other hand, when I took off the glasses, or moved my head up and down, the heavy feeling in the back of my head continued until I put the glasses back on. Then the feeling went away," he said.

The Day's Impressions:

"On Day 1, I felt a great deal of psychological stress. Because the outside world was all upside down, I constantly had to be careful of the arrangement of objects. When walking, I wondered if there was an object in my path and I continually had to start and stop. I couldn't really read characters and

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to go where they wanted to, it took a great deal of time.

Walking and so forth was very clumsy.

Notes

1) Eccles, J.C. : The brain and the unity of conscious experience, Cambridge University Press, London, 1965.

2) Eccles, J.C.: The understanding of the brain, McGraw-Hill, New York, 1973.

3) Evert, P.H.: A study of the effect of inverted retinal stimulation upon co-ordination behavior, Genet. Psychol. Monogr. 7:177, 1930.

4) Fujiwara Masahiro, Nakao Takehisa, Nonomiya Hideaki, Ikeda Teruchika: Gyakutenshiya ni Kansuru Shinrigakuteki Ichikosatsu (A Psychological Study of the Inverted Visual Field). to be published in Kyushinseii.

5) Helmholz, H. von: Treatise on physiological optics, 1866. (translated and edited by J.P.C. Southhall) vol. 3, Dover, New York, 1962.

6) Harris, C.S.: Adaptation to displaced vision: Visual, motor or proprioceptive change?, Science, 140: 812, 1963.

7) Harris, C.S.: Perceptual adaptation to inverted, reversed, and displaced vision, Psychol. Rev., 72: 419, 1965.

8) Kohler, I.: Umgewohnung im Wahrnehmungsbereich,Pyramide, 5:92, 1953.

9) Kohler, I.: Die Methode des Brillenversuches in der Wahrnehmungspsychologie; mit Bemerkungen zur Lehre der Adaptation, Z. exp. angew. Psychol., 3:381, 1956.

10) Kohler, I.: The formation and transformation of the perceptual world, Psychological Issues (translated by Fiss, H.), 3:1, 1964.

11) Katori Hiroto, Chikaku - Undō Kyōō, Wada Yōhei, Oyama Masao, Imai Shogo: Shinrigaku Handobukku (Psychology Handbook), 140, Seishin Shōbō, Tokyo, 1969.

12) Kachiki Yasutsugu: Kankaku no Chitsujo, Nō no Seirigaku (Learning and the physiology of the brain), Chapter 4, p. 168, Asakura Shoten, Tokyo, 1966.

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didn't feel that I could really see the world around me. My ability to concentrate and be careful decreased remarkably."

(2) Day 2

The subjects became somewhat more active. Saying, "staying quietly in the room is boring," they did such things as buy newspapers at the hospital bookstore and use the pay phone. Also, they went out on the roof near the ward and practiced walking along a straight line on the floor. They said to the researchers, "I've gotten somewhat used to the upside down world but when I try to walk quickly, because my field of vision is narrow, I keep bumping against the chairs and other objects that are placed in the hallway." They began to mix with the other patients in the ward and to watch T.V. Because they said that they could read a little, we experimented with transcribing words and phrases. But they were very clumsy and made mistakes in the stroke order when writing characters and sometimes wrote horizontal lines from right to left and vertical lines from bottom to top. (Note: it is possible to write Japanese either vertically or horizontally.) But it was possible to read what they had written.

E.U.: "The discomfort from the oscillation of the visual field and the feeling of unnaturalness about the outside world decreased somewhat. It got so that it didn't really bother me when I looked at the T.V. or other things that were upside down. But because when I looked at people they seemed to be upside down, /259

13) Makino Tatsurō: Gyakutenshiya no Chikaku (Perception in an Inverted Visual Field), Jinbun Kenkyū (Osaka University), 14: 157, 1963.

14) Makino Tatsurō: Shikukan no Teii to Shintaiundō (Movement and Location in Visual Space), Ōyama Masao, ed., Shozashinrigaku 4 Chikaku, 191, Tokyo, 1976.

15) Makino Tatsurō: Sakasa no Sekai - Jiko to Gaikai (The inverted world -- the individual and the outside world), Tetsugakushi (Philosophical Magazine), 4:1, 1976.

16) Nakao Takehisa, et. al.: Gyakutenshiya e no Tekiō ni Kansuru Kenkyū - Kakushu Kensa ni yoru Kentō (Research related to adaptation to an inverted visual field -- an investigation of various tests), Kyūshin Seii, 1980.

17) Nakamura Yujirō: Kyōtsūkankuron (A theory about intengrated senses), Iwanami Shoten, Tokyo, 1980.

18) Rock, I.: The nature of perceptual adaptation, Basic Books, New York, 1966.

19) Rock, I. And Harris, C.S.: Vision and Touch, Sci. Amer., 216: 96, 1967.

20) Stratton, G.: Some preliminary experiments on vision without inversion of the retinal image, Psychol. Rev., 3: 611, 1986.

21) Stratton, G. M.: Vision without inversion of the retinal image, Psychol. Rev., 4:341, 1897a.

22) Stratton, G.M.: Vision without inversion of the retinal image, Psychol. Rev., 4:463, 1897b.

23) Welch, R.B.: Research on adaptation to rear-ranged vision, Perception, 3:367, 1974.

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VISUO-MOTOR ADAPTATION AND CHANGE OF SUBJECTIVE SENSE DURING INVERTED VISION

by

Hideaki Ninomiya, Masahiro Fujiwara
Terutika Ikeda

I couldn't really read their expressions. I took off the glasses when it was time for dinner, and when I was carrying my dishes my head felt funny for a moment or two and I felt dizzy as if I were seasick. But after four or five minutes, I soon recovered," he said.

The Day's Impressions:

The degree of fatigue lessened compared to Day I. As for watching T.V., it was interesting, but still I soon got tired. People and plants didn't look like they were alive, seemed unreal, and looked flat and unchanging. But music that I listened to on a tape recorder sounded more lively than usual.

M.T.: 'Today, the feelings of strangeness were somewhat decreased compared to Day I. However, when I looked at people or physical objects, I could make out the shape but I could not make smaller distinctions such as whether they were hard or soft. In addition, I could not make out the small changes in people's expressions at all. It wasn't an extraordinary physical obstacle, but when I took off the glasses to eat, my head shook up and down and felt heavy for awhile and I felt dizzy. After about ten minutes I put the glasses back on and the feelings went away," he said.

The Day's Impressions:

'Sight works for the body to prepare it for making ordinary movements, doesn't it? Also, when not using these glasses, sight has a preparatory function and also works to decrease stress in dealing with physical objects. When wearing the prism glasses,

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Introduction

In our previous paper [17] we reported on the progress of adaptation to an inverted visual field created by prism glasses from observations of the subjects' behavior and their reports of their experiences. This paper will give the results of several visual-motor tests conducted throughout the period of the experiment as well as report changes in the level of activity, and subjective evaluations of the experiment by the same subjects.

Subjects and Methods

The subjects were two healthy adults, E.U. and M.T., both 23 years old and Miyazaki Medical College students. The experiment was conducted over a one week period during which the subjects were admitted to a ward of the psychology department of a hospital connected with the Medical College. The details of the research methods were reported previously.[17] The inversing prism glasses were glasses for both eyes that used rectangular prisms (manufactured by Takei Kiki). These glasses reversed top and bottom of the image with the prisms and created a narrow field of vision (vertical 27°, horizontal 40°). For comparison in each experiment, glasses that restrict the visual field that were made by the researchers were used at the same time as the inversing prism glasses.

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not only do you not receive the necessary information, but stress from the outside world increases, doesn't it?"

(3) Day 3

The subjects became more active and didn't lie down in the ward; they strolled frequently about the hospital. They said, "I'm getting used to an upside down world," and "I have become comparatively able to handle my personal property and so forth that is in the room." Because they also said, "I can decipher my medical textbooks a little," we administered a transcription test with short and long sentences. It took them quite a bit of time, but it was possible for them to do it. The instability in the visual field decreased quite a bit, but one subject stated, "When I'm talking with a friend, it's like seeing the friend on video and talking to him or her on the phone; things still don't seem real."

E.U.: "I have gradually become used to the upside down world. Even when I did the various tests, I wasn't very tense. I had the will to try and do them. But I felt estranged from the outside world. I began to feel like talking with the other patients in the ward, but the feeling of strangeness that friends and the other patients were in another world continued. When I removed the glasses at dinner time, I began to feel quite dizzy. This continued for about ten minutes and was especially obvious when I nodded my head up and down. It went away when I put the glasses back on. The world is all standing upside down, but it's gotten so that it doesn't really bother me."

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The tests that were conducted were as follows:

1) Cutting circles: circles 6cm in diameter that were drawn on small sheets of paper (14.5cm x 10.5cm) were cut out with scissors.

2) Copying words: the subjects wrote five words in phonetic characters (hiragana) and in Chinese characters (kanji).

3) Copying short and long sentences: short sentences of forteen characters in length and long sentences of 175 characters.

4) Copying figures: subjects drew a picture of a house.

5) Level of activity: the subjects strolled freely about the hospital in their free time. The distance that they walked each day was calculated by marking the route they walked on a rough plan of the hospital.

6) Subjective evaluation of feelings of strangeness because of the glasses: a) oscillation in the visual field; b) feelings about the reality of the outside world; c) feelings of dizziness after removing the glasses; these were given a rating of 0 to 5 every day.

Results

1) Cutting Circles (Figure 1)

The task of cutting out circles 6cm in diameter is usually done in one continuous motion while turning the paper. But using the scissors with the prism glasses is extremely difficult. First, it is a problem to bring the scissors to the right place on the paper. Next, to determine the direction to use the scissors

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The Day's Impressions:

"Concerning human beings' superiority to animals, humans are quicker to adapt to a changing environment, and they adapt well."

M.T.: "Today I could read even the fine print in the newspaper. I made quite a bit of progress in walking. However, it is confusing when I enter a place where there are many people. The reason is perhaps that I still can't judge distances very well. Things and people that are close seem large and ones that are in the distance seem small. The world, after all, is upside down, and I still don't see things correctly." But he stated that he is not strongly conscious of the obstacle to his vision.

The Day's Impressions:

"I took a test of what is left and right in a picture. After the test when I asked the other patients, I found out that we had guessed left and right incorrectly. The world still lacks a feeling of reality and I feel dizzy when I remove the glasses."

(4) Day 4

Both of the subjects began to say, "We feel that the rhythm of our lives has returned to what it was like before we put on the glasses." They became more active than on the previous day and went out to the classroom and the laboratory and were able to read their medical texts. They began to say such things as, "I still feel that the outisde world lacks reality. But I have been able to rely on my vision while moving." /260

they moved the scissors over the paper, but with the visual guide they ended up confused. FIgure 1 shows the time required for this task. But, as shown by C, although it is a task that usually requires about 23 seconds, in the situation where the glasses were first put on it required more than 200 seconds and the circles were rough and irregular. (P: a test of both subjects before the experiment began.) On Day 1 after the subjects had gotten used to the glasses for several hours, the task took more than 100 seconds and the cut-outs were rough. But on Day 2 the time was reduced to about 50 seconds (comparatively two times normal) and they were able to cut in one motion without changing their grip on the scissors. After this, the time required gradually approached normal. This shows that for a task using scissors that is basically a comparatively simple case of hand-eye coordination like cutting circles, the subjects will become adapted and able to perform the task after wearing the glasses for one to two days.

2) Copying Words (Figure 2)

This test was conducted on Day 3 and Day 6. The subjects were asked to write the five hiragana (phonetic, cursive characters) and kanji (Chinese characters) words shown below Figure 2. These tasks usually require 16 and 27 seconds respectively, but on Day 2 the hiragana words took more than 100 seconds and more than 60 seconds on Day 6. The kanji words took more than 180 seconds on Day 3 and more than 130 seconds on Day 6. For the kanji task on Day 3, there was a great difference between the two subjects/266

E.U.: "I feel that we have passed the peak of this thing. Yesterday there were many times when vision with the glasses was a hinderance to action, but today I find that I am not particularly conscious of that. The world is still upside down but I realize that I don't particularly notice that it is upside down. I still don't feel that things are alive. But when I look at something and think that I'll pick it up, I'm able to go right to the place where it is."
The Day's Impressions: "The world is still upside down. But compared to Day 3, I was able to observe more small details. I was able to grasp the door knob quickly, but handling things like putting tooth paste on a tooth brush were still difficult. I still can't compensate very well visually for those aberrations caused by wearing the glasses."

M.T.: "I became able to accomplish all physical activities better than yesterday. When other people began to talk to me, it became natural for me to turn my whole head in that person's direction because my field of vision was narrow. Usually, when talking with someone or when following a person with one's eyes, you just keep them in your line of sight by moving your eyes. But when you put on these glasses, the visual field is narrow, so soon the person will disappear from sight. Sometimes I don't move my head, or I turn my head too far, or move it excessively, and the field of vision shakes. But today I'm able to do that kind of thing naturally. I learned to turn together with the movement of my objective to get it in my field of vision. /260

This seemed to be related to the attitude that the subjects had about copying.

In the case of copying, for hiragana and simple kanji a visual guide is not necessary to write the character. On the other hand, for complex characters, to correctly place the left and right sides of the character a visual guide is necessary. When the subjects tried to write hiragana or simple kanji accurately with a visual guide, the prism glasses ended up being a hinderance. For copying, the differences in the time required to copy the sentences by the subjects appears to result from a difference in attitude that depends on the visual guide.

3) Copying Short and Long Sentences

a) Copying Short Sentences (Figure 3)

Sentences of 14 characters that are a combination of Chinese characters and phonetic characters can usually be written in about 16 seconds. This test was conducted from Day 2 on. On Day 2 it required more than 120 seconds. This test showed the same difference between the subjects that was seen before in the word transcribing test. In short, subject E.U. required 50 seconds more time than M.T. did. However, this differences disappeared from Day 4 on. That is, until about Day 3 of the experiment differences in attitude between the subjects seemed to appear, but after than the differences disappeared. On Day 3 the time required decreased to a maximum of 30 seconds for both subjects, and it now took them only twice as much time as normal.

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The outside world was inverted and I didn't see it upright, but I could see scenes and changes in people's expressions in detail. But it was like seeing the world through a thick glass door, and when I looked at a person it was like seeing them reflected in a mirror. The feeling of dizziness when I removed the glasses was gradually getting stronger.

The Day's Impressions:

"I think that we passed the day comfortably without tension. We were able to finish such activities as transcribing sentences fairly quickly."

(5) Day 5

"We were confused by activities that required careful thought, but for exercise or walking, they were close to our normal state without wearing glasses. But the world was all inverted and we couldn't see anything correctly. But around noon, when walking down a hallway that looked symmetrical, when I looked up at the ceiling I thought for an instant that I was seeing things right side up. But when I looked carefully, it was still reversed after all. Perception of distances still had not completely returned to normal. I thought that people and scenes looked as though reflected in a mirror and seemed unreal," one of the subjects stated. One of the researchers asked, "How would it be if you wore the glasses for twenty years?" "If the field of vision were wider, I don't think it would seem inconvenient," they answered.

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b) Copying Long Sentences (Figure 4)

On the third day using the prism glasses, because we found that the subjects could do the copying fairly well, a test of copying sentences that were 175 characters long and that contained both Chinese characters and phonetic characters was administered from Day 3 on. The copying of these sentences can normally be completed in about 4 minutes 17 seconds, but on Day 3 it took more than 17 minutes. By Day 7 they were able to do it in about half the time, eight to nine minutes, but this was still twice as much time as normal.

4) Copying Figures (Figure 5)

The copying of a simple line drawing of a house can usually be done in less than 16 seconds. But when done with the prism glasses, the time averaged 288 seconds (N=17) and clearly the time increased. Also, the figure was poorly drawn. It took 50 seconds on the sixth day wearing the glasses, 40 seconds on the seventh day and by then the subjects were able to draw the figure smoothly. This was still two to three times the amount of time normally required. Figure 5 shows E.U.'s drawing before the experiment began and he had experienced the glasses, and also his drawing on Day 7. As can be seen from the figures, when not yet adjusted to the glasses, placing the pencil on the right point and moving it in the right direction take several unsteady attempts.

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E.U.: "I think that I've pretty much become accustomed to the inverted world. But things that should fall according to the natural laws of gravity accelerate and rise instead. And I feel uneasy about things like tabacco smoke "rising" downwards."

The Day's Impressions:

"The times when I am able to move without being conscious that I am wearing the glasses are gradually increasing."

M.T.: "The outside world was all inverted, but I didn't feel that there were really any obstacles to movement. Perhaps this shows that it doesn't really matter if things are seen upside down. If the concepts that I create in my own mind about the outside world are not contradicted by other people, then I think that whether the image is right side up or upside down is not significant."

The Day's Impressions:

"There was no obstacle to normal activity. Just when I made precise movements my vision was a hinderance. Also, the dizziness when I take off the glasses seems to be increasing."

(6) Day 6

Except that they were using the glasses, the subjects' activities were for the most part close to normal. "In the morning I did calisthenics to the radio with the other patients and in the afternoon played ping pong. But because the ball moves quickly, it would soon go out of my field of vision. When I swung the paddle, I often swung above the ball and missed.

5) Each Day's Level of Mobility (Figure 6)

As stated in the Methods section, the distance the subjects walked every day was calculated using a map based on the subjects' reports. C in Figure 6 shows the average distance that the subjects walked during the six days following the experiment. Generally, they walked 1500 meters daily. On Day 1 of the experiment the subjects were still not adapted to the glasses and activity was limited. They could barely leave the room to go to the toilet, and they walked feeling their way along the corridor. When they wore the glasses, not only were things seen upside down, but the visual field was narrow, and in order to see where they were going they had to tilt their heads very far forward. If they move their heads, the visual field shakes. The things that they are looking at are unstable. They can't judge distances. Because of this, movement is restricted. But because we told them to use their time actively doing such things as walking, watching t.v., or reading, the subjects tried to do these things.

On Day 1 the subjects could barely go to the gift shop to do some shopping, but the distance they walked increased as the days passed. On Day 5 the distance was up to about 2000 meters, and they even walked more than they usually did. When it reached this level, they had gotten used to walking in the hallways and on the stairs and could move about pretty freely. Because they could

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If I could rally two or three times, usually that was the best I could do. After all, the world is upside down, and I was not able to see things correctly."

E.U.: "I could move more skillfully than yesterday. From the six days' experiences, maybe I can suggest that "seeing correctly" means a situation in which one can move skillfully and naturally without being aware that things are upside down.

When doing something like eating with the glasses off, there is a feeling of dizziness and the world doesn't seem real. But this feeling of unreality is lessening every day. The oscillation in the visual field has also decreased."

The Day's Impressions:

"I still can't really tell distances or if things are solid or not. Even if I get used to the world upside down, I think that to be able to grasp these differences correctly will come very slowly."

M.T.: "Today even though there were tests, they were not difficult. When transcribing sentences, I was able to write in my usual style. The world was upside down but this was not troublesome."

The Day's Impressions:

"I became able to live looking at the world upside down without being conscious of it. But when I was asked if I saw things right side up, I had to answer, 'The image is upside down.' When I did something like scoop up ice from a plate with a spoon, I was hampered by my vision. If I were to go into a place where

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and 2 it lasted for five or ten minutes after taking off the glasses, but by Days 5 and 6, even while removing the glasses, not only were they dizzy, but they experienced a loss of reality like that they had experienced when they first put on the glasses. The loss of reality and dizziness that occurred when they moved after they removed the glasses when the experiment was over were evaluated over time as shown in the graph. These feelings continued for three or four days and then returned to normal. This effect was especially strong for E.U. Because of this, the subject stated that during that period he couldn't drive a car. P on the graph shows the degree of dizziness and feelings of unreality when the subjects put on the glasses briefly when they came in one week and two weeks after the end of the experiment to let us make polygraph recordings. But there was little oscillation in the visual field and also only slight dizziness when they took off the glasses. This means that the adaptation to the glasses continues for one to two weeks.

Considerations

As was mentioned in the Considerations section in our previous publications,[17)18)] the issue of adapting to the inverted visual field is roughly divided as follows: 1) The visual field becomes upright.[14)15)24)25)26)] 2) There is no change in vision, but there is physical adaptation to the inverted visual field.[3)6)7)21)23)27)] The issue is being debated from these two sides.

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Concerning the latter physical adaptation theory, there are various opinions. Many theories have been put forward, such as a reordering of the senses to create unity between vision and movement,[18] rearrangement of perceptions of the body,[13] and the theory that emphasizes the role of a sense of location.[12] In any case, dealing actively with the inverted world will speed up learning.[8)9)10)11)19)29)21] Concerning a change in visual perception, in our previous papers from observations of change in subjects' activity and reports of the subjects' experiences we found that upright vision did not occur even temporarily during a week of wearing the prism glasses. Our findings contradict Stratton [26] and Makino.[14)16]

Among the research with inversing prism glasses, this report deals with the change over time in the visual-motor response, the amount of activity, and subjective evaluations of feelings of unease. When we analyze the results, for all the tests there are shortened performance times and improvement in performance of the tasks over time. For example, for circle cutting there was rapid improvement within two or three days and performance approached normal.

As touched on briefly before, the test scores of the two subjects that participated in this experiment show the same trend, but there were some differences. Overall, in the early part of the experiment E.U.'s scores were worse that M.T.'s.

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"I was able to handle the various tests comfortably. The world still doesn't seem alive; it seems unreal. There is also oscillation in the visual field, today dizziness is stronger, and it stops when I put the glasses on."

Considerations

Concerning distortion of vision, adaptation, and the after-image effect, according to experiments by Helmholz and others[4] distortion of vision caused by using a prism is known to decrease within a comparatively short period of time. Based on this study, Stratton[21][22] found that the world is seen right side up in spite of the fact that the image on the retina is upside down. And, wearing the prism glasses, the world is reversed and the image on the retina is actually right side up. The result of wearing the prisms is first that the world is seen upside down and vision predominance disappears. The person begins to rely on the evidence of the other senses, that is, hearing and touch, and proprioceptive sensation becomes predominant. The senses are in disorder, and the subjects are confused. From the second day of Stratton's experiment, the world looked right side up and, following the all-or-none law, what had been seen upside down until then was intermittently seen correctly. Both the frequency and the duration increased; there was no time when they saw the image both ways.

This kind of right side up vision increased with the passage of time during the experiment. The feeling that the world was

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But that was only in the beginning. After three or four days, they were both at the same level. Figure 8 compares both subjects on three tests. These differences show differences in reaction to the sudden inversion of the visual field between the two subjects. Various factors may account for this. The authors, in a different experiment with 18 subjects, had the subjects write their own names while wearing the prism glasses and then write them with their eyes closed. The results were that when wearing the glasses the average time was 220.7 seconds (greatest, 485 seconds; least, 36 seconds), when the subjects' eyes were shut the average was 43.3 seconds (greatest, 64 seconds; least, 23 seconds). This shows that it is faster to write one's own name with the eyes shut, and of course it shows that with the glasses visual control in disturbed. Also, because the range of times varied greatly, individual differences in dealing with the effects caused by the glasses are shown to be great. Also, perhaps the subjects, when given this kind of task, will write according to their mental image instead of relying on a visual guide. Actually, there are many instances in the early stages where it was better to move according to a mental image than to use vision as a guide.

In addition, Figure 8 shows differences in adapting to the different tests. For simple tasks like circle cutting, it shows that subjects progress within a week to the point that they are no different from the control. But for copying sentences,

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they only reach the level of two times the control, and if copying only Chinese characters they improve to the point where they require four to five times the normal amount of time. Thus, the degree of difficulty of the test seems to be, for any test, the extent to which the subjects use the visual guide or

severe for the first two to three days and decreased after that. When they had become adjusted to the glasses, by contrast, they began to feel strange when they took them off. This relationship was shown by the evaluations of their experiences and changes in their level of activity. Because feelings of unease occurred when they took the glasses off, as the last day of the experiment approached they preferred to wear the glasses.

When the one week experiment ended, the subjects were liberated from the heavy prism glasses, but again for two or three days they had feelings of strangeness. These were fairly mild, but it was similar to when they had first put on the glasses. After that their vision returned to normal, but when we later tried to test them with the glasses we found that they adapted very quickly.

The problem of adapting to the prism glasses is of course a sensory problem. In this experiment we offer data that makes suggestions about recognition of the outside world, perception, and motor learning. Also, the unease from dizziness that occurs when putting on the glasses can be seen as a problem of eye movement and the equilibrium function of the eyes, or as a brain function from the inner ear to the mid-brain and corebellum. 1)2)4)5)22) Moreover, when inverted vision is used as a stimulus, the individual response to that stimulus can be thought of as a measure to judge individual attitudes.

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and personality may be overlooked.

Furthermore, if the subjects are of different ages, differences in adapting to the inverted visual field also can be expected. In the research mentioned above, there are doubts about whether or not the important part of adaptation to the inverted visual field was correctly interpreted or not. Concerning this point, one of the authors plans to publish a separate study based on the results of the various psychological tests.[7)]

In view of the above points, the authors decided to use the research methods that they did in this study. That is, the subjects and the researchers were not the same persons, the subjects were admitted to a ward of the hospital and wore the glasses there so that they could be easily observed, and, in this way, information was obtained by both observation and report.

The results obtained by the authors are very different from those reported by Stratton and Makino. For example, according to Stratton's research, adaptation to the inverted visual field was comparatively fast. His subjects even saw the visual field right side up on the first day of his experiment. But ordinarily the visual field was inverted and disturbed. On Day 2, they became able to see themselves right side up. Moreover, on Day 3, the disturbance in the visual field decreased and they became aware of movement of their own bodies not just when it could be seen in the visual field. On Day 4, they saw the visual field correctly more often, especially when they were moving they felt

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Summary

Experiments were carried out using inversing prism glasses for one week with two adult male subjects. The results of various sensory-motor tests, measurements of the level of activity, and subjective evaluations of the subjects' experiences were reported.

For sensory-motor tests such as circle cutting, copying sentences and copying figures, these could be accomplished fairly well by Day 3 and Day 4 of the experiment. This was related to the degree of difficulty of the task. Circle cutting could be done almost as well as the control. For copying sentences, the subjects adapted to the extent that they could do it in two to three times the time required by the control. In the one week experiment, even temporary upright vision was not seen. According to the subjects' accounts of their experiences, they said that they could move about freely and it did not matter whether vision was right side up or upside down.

The oscillation in the visual field and the lessening of feelings of reality were created by the prism glasses but when they continued to wear them, a feeling of unease and temporary dizziness occurred when they took them off. When we had the subjects make subjective evaluations of these experiences, they said that the oscillation in the visual field and the loss of a sense of reality lessened as the days passed, but at the same time the feelings of uneasiness when they took off the glasses got stronger.

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that things were right side up and realistic. On Day 8, it was reported that there was agreement between vision and hearing and vision and touch. They were able to turn their heads in the direction of a crackling fire, for example, and the pencil that the subject took in his hand agreed with the one that he saw in his field of vision.

Moreover, according to Makino, his research was different from Stratton's. But concerning "right side up vision" and "right side up," he regulated more clearly that Stratton did the progress from inverted to right side up that is the all-or-none law [13)14)15)] and saw no middle ground. The frequency of seeing right side up and the duration of "correctness" increased with time, he found.

Stratton, as a basis for judging whether vision was inverted or not, had to turn to evidence from senses other than vision. As for correct vision, it occurred in the instances where visual and tactile evidence or visual evidence and body sensation were in agreement. Furthermore, he stated that body orientation had a great deal to do with correct or inverted vision. Makino is also seeking evidence that right side up vision is related to physical orientation.[14)] There is no agreed upon answer on this point as yet.

Evert[3)] did an experiment using the inversing prism for both eyes that was used by the authors. Two weeks after the experiment

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and they found that there was this inverse relationship. Also, after the one week experiment ended, the feelings of uneasiness continued for two to three days and this seemed much like when they had first worn the prism glasses. By measuring the subjects' level of activity, we found that along with the subjects' adaptation to the glasses, the distance they walked increased.

Differences in the degree of adaptation to the prism glasses could be seen between the two subjects. This can be thought of as reflecting differences in attitude related to individual methods for solving the problems created by the inverted visual field.

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began the subjects performed vitually all activities with the glasses on and they had adapted to the view that they saw of the outside world, but they reported that the world remained upside down. Kohler[10] found that adaptation to activity in the outside world could be seen fairly soon, and that even though the subjects adapted almost completely they saw the world upside down and not correctly right side up. In this experiment, the authors conducted various tests focused on changes over time in the physical sensations[12] such as touch, the sense of pain, motor awareness, and the senses such as vision and hearing. At the same time we observed changes in activity and kept records of the subjects' impressions. We analyzed the data and found that adaptation is slower for fine motor skills that require a visual guide than for activities that comparatively do not require a visual guide.[1)2)11)] We think that these results can be used as an index of changes in perception that are related to the inverted visual field and the degree of adaptation to the world when seen upside down.

On the other hand, there is criticism of our way of conducting the experiment in that we used change in movement and activity as an indicator of change in vision (Makino, 1976[14]). But the objective of this paper was to present the subjects' impressions and the changes in their behavior. Later, in a separate paper the research will be presented in more detail.

The authors feel that, inspite of the fact that neither subject

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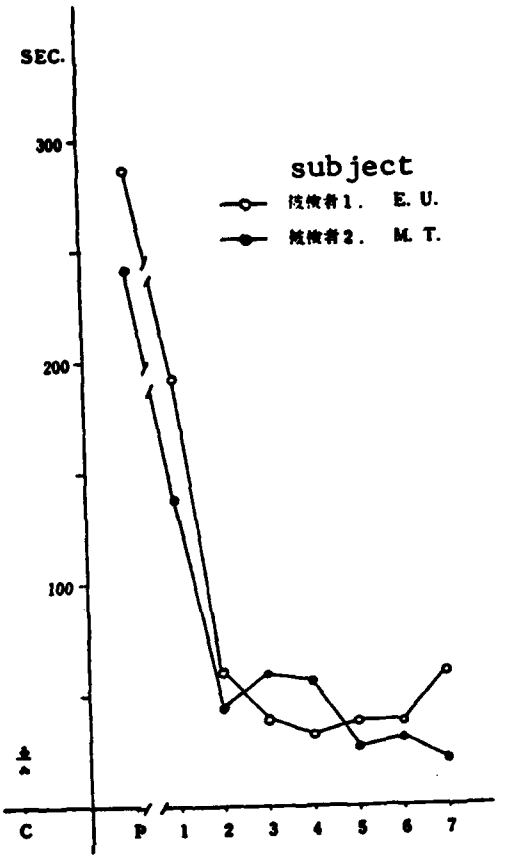

Figure 1: Circle Cutting: C is the control, P is the result at the beginning of the experiment. The vertical axis shows the time required, the horizontal shows the day the test was done.

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saw the world right side up, because of the subjects' activity with an inverted field of vision and their fairly good adaptation, this research comes close to the results obtained by Evert[3)] and Kohler[10)]. That is, they adapted well in their activities, so perhaps we can say that they began to not be aware that the world was upside down. There is a restructuring [1)2)] of body awareness and the corresponding senses including sight. It is thought that this is related to a learning process that connects sight and movement (Katori, 1969[11)]).

The authors' research took place over a period of one week and this was shorter than previous studies that lasted from eight to thirty-seven days. If the research had continued for a longer period of time, the results might have been different, but this is only speculation. The thing to note here, is that while feelings of unease from oscillation in the visual field and feelings of strangeness decreased over time, distance perception, according to the two subjects, was slower to change. For example, oscillation was not seen in a horizontal direction parallel to the reflecting surface of the glasses. This is an optical characteristic of the prism, and it goes away or decreases during the course of the experiment. Stratton[21)22)] recognized this in his experiments when the visual field was reversed using a prism, and it is known to be a characteristic of inverted vision. Also, in contrast, dizziness when the glasses are removed became stronger and ceased when the glasses were put back on. This study suggests that an individual will adapt /263

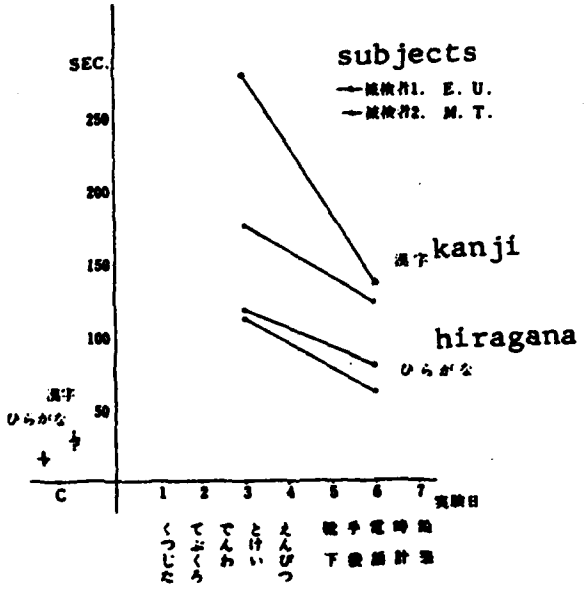

Figure 2: Copying Words. This was a test of kanji (Chinese characters) and hiragana (phonetic characters). The words used are shown below the graph.

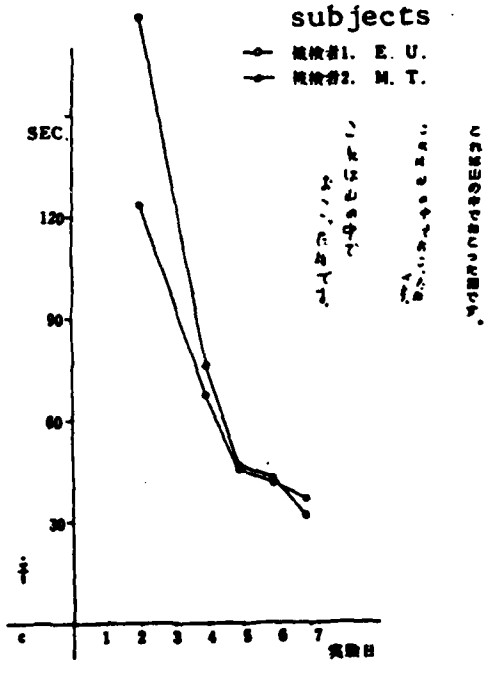

Figure 3: Copying Short Sentences. Next to sample are shown E.U.'s sentences for Day 2(center), and Day 7 (left).

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to vision inverted by means of a prism. But these problems are not insignificant and careful consideration is necessary. When we give the results of various tests in a separate paper, these results will be given further consideration.

Summary

In order to do a detailed study of physical adaptation and sensory adaptation, various experiments were conducted on the process of adapting to a world that looked upside down when inversing prism glasses were used. In addition, speculative studies were done and records kept of the subjects' impressions. This paper focused on observations of the subjects' behavior and records of their impressions during the experiment and compared the methods and results with previous studies.

The subjects were two healthy students from the Miyazaki Medical College who spent one week in a ward of the Psychology Department of a hospital connected with the Miyazaki Medical College. They wore the inversing prism glasses, and various tests -- psychological tests and others -- were conducted throughout the one week period of the experiment. Records of impressions and changes in the subjects' behavior were also kept.

First, to look at the process of adaptation, on Day I of this experiment, instability in the visual field was clear, the world seemed to shake, there was a feeling of unreality and an inability to make out characters, although the subjects were able

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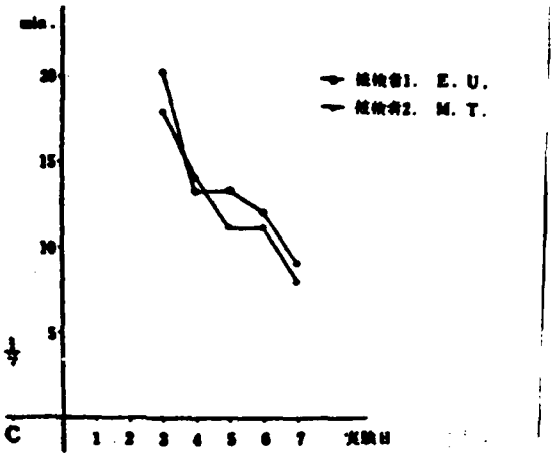

Figure 4: Copying Long Sentences.

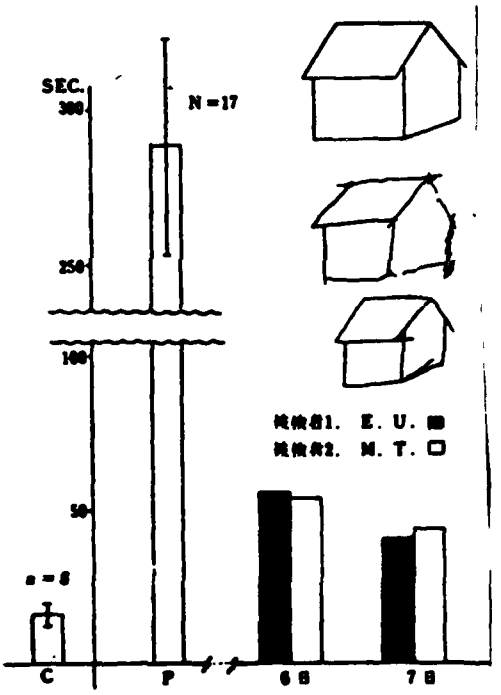

Figure 5: Copying Figures. C is the control (n=8), P was at the time they first put on the glasses (n=17). The center figure was the right was drawn by E.U. at P, the bottom on Day 7.

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to go where they wanted to, it took a great deal of time.

Walking and so forth was very clumsy.

Notes

1) Eccles, J.C. : The brain and the unity of conscious experience, Cambridge University Press, London, 1965.

2) Eccles, J.C.: The understanding of the brain, McGraw-Hill, New York, 1973.

3) Evert, P.H.: A study of the effect of inverted retinal stimulation upon co-ordination behavior, Genet. Psychol. Monogr. 7:177, 1930.

4) Fujiwara Masahiro, Nakao Takehisa, Nonomiya Hideaki, Ikeda Teruchika: Gyakutenshiya ni Kansuru Shinrigakuteki Ichikosatsu (A Psychological Study of the Inverted Visual Field). to be published in Kyushinseii.

5) Helmholz, H. von: Treatise on physiological optics, 1866. (translated and edited by J.P.C. Southhall) vol. 3, Dover, New York, 1962.

6) Harris, C.S.: Adaptation to displaced vision: Visual, motor or proprioceptive change?, Science, 140: 812, 1963.

7) Harris, C.S.: Perceptual adaptation to inverted, reversed, and displaced vision, Psychol. Rev., 72: 419, 1965.

8) Kohler, I.: Umgewohnung im Wahrnehmungsbereich,Pyramide, 5:92, 1953.

9) Kohler, I.: Die Methode des Brillenversuches in der Wahrnehmungspsychologie; mit Bemerkungen zur Lehre der Adaptation, Z. exp. angew. Psychol., 3:381, 1956.

10) Kohler, I.: The formation and transformation of the perceptual world, Psychological Issues (translated by Fiss, H.), 3:1, 1964.

11) Katori Hiroto, Chikaku - Undō Kyōō, Wada Yōhei, Oyama Masao, Imai Shogo: Shinrigaku Handobukku (Psychology Handbook), 140, Seishin Shōbō, Tokyo, 1969.

12) Kachiki Yasutsugu: Kankaku no Chitsujo, Nō no Seirigaku (Learning and the physiology of the brain), Chapter 4, p. 168, Asakura Shoten, Tokyo, 1966.

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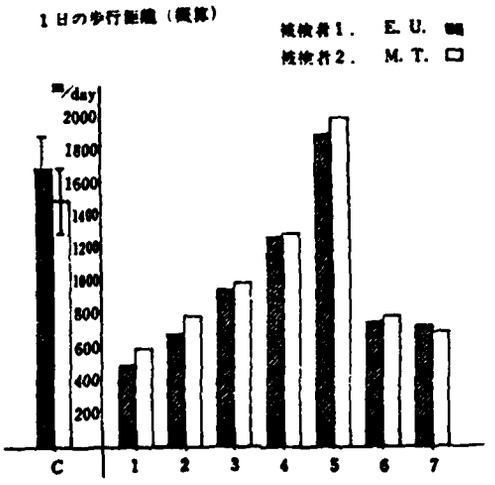

Figure 6: Distance Walked Each Day. C shows an average daily distance for the subjects calculated over a six day period.

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13) Makino Tatsurō: Gyakutenshiya no Chikaku (Perception in an Inverted Visual Field), Jinbun Kenkyū (Osaka University), 14: 157, 1963.

14) Makino Tatsurō: Shikukan no Teii to Shintaiundō (Movement and Location in Visual Space), Ōyama Masao, ed., Shozashinrigaku 4 Chikaku, 191, Tokyo, 1976.

15) Makino Tatsurō: Sakasa no Sekai - Jiko to Gaikai (The inverted world -- the individual and the outside world), Tetsugakushi (Philosophical Magazine), 4:1, 1976.

16) Nakao Takehisa, et. al.: Gyakutenshiya e no Tekiō ni Kansuru Kenkyū - Kakushu Kensa ni yoru Kentō (Research related to adaptation to an inverted visual field -- an investigation of various tests), Kyūshin Seii, 1980.

17) Nakamura Yujirō: Kyōtsūkankuron (A theory about intengrated senses), Iwanami Shoten, Tokyo, 1980.

18) Rock, I.: The nature of perceptual adaptation, Basic Books, New York, 1966.

19) Rock, I. And Harris, C.S.: Vision and Touch, Sci. Amer., 216: 96, 1967.

20) Stratton, G.: Some preliminary experiments on vision without inversion of the retinal image, Psychol. Rev., 3: 611, 1986.

21) Stratton, G. M.: Vision without inversion of the retinal image, Psychol. Rev., 4:341, 1897a.

22) Stratton, G.M.: Vision without inversion of the retinal image, Psychol. Rev., 4:463, 1897b.

23) Welch, R.B.: Research on adaptation to rear-ranged vision, Perception, 3:367, 1974.

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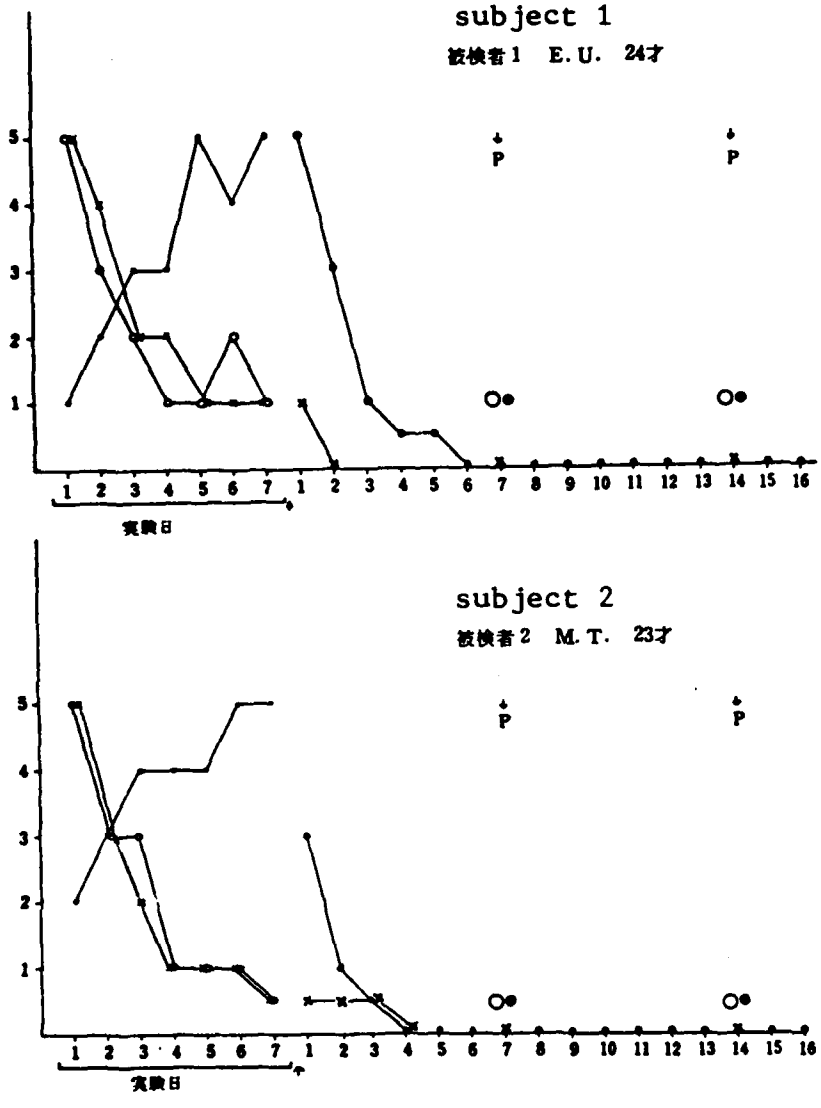

Figure 7: Subjective Ratings of Feelings of Unease. · indicates feelings of dizziness when glasses were removed. ○ indicates oscillation in the visual field at the time the glasses are put on. x indicates feelings of unreality when wearing glasses. After experiment, ● indicates periodically occurring dizziness, ○ feelings of unreality. P are times subjects came in to take polygraph tests.

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VISUO-MOTOR ADAPTATION AND CHANGE OF SUBJECTIVE SENSE DURING INVERTED VISION

by

Hideaki Ninomiya, Masahiro Fujiwara
Terutika Ikeda

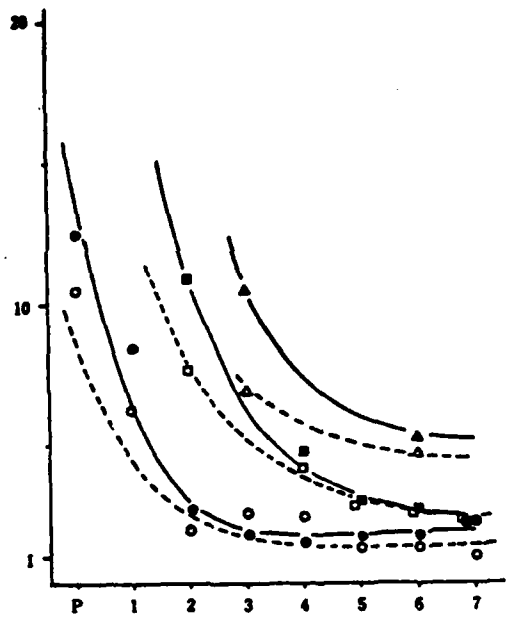

Figure 8: Shows the results for both subjects on three tasks compared to the control. Circle cutting (circles), copying Chinese characters (triangles), and copying short sentences (squares). Black is E.U., white is M.T. The vertical axis gives the subjects' times in comparison to the control (for example, two times the control). P is when they had first put on the glasses.

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Introduction

In our previous paper [17] we reported on the progress of adaptation to an inverted visual field created by prism glasses from observations of the subjects' behavior and their reports of their experiences. This paper will give the results of several visual-motor tests conducted throughout the period of the experiment as well as report changes in the level of activity, and subjective evaluations of the experiment by the same subjects.

Subjects and Methods

The subjects were two healthy adults, E.U. and M.T., both 23 years old and Miyazaki Medical College students. The experiment was conducted over a one week period during which the subjects were admitted to a ward of the psychology department of a hospital connected with the Medical College. The details of the research methods were reported previously.[17] The inversing prism glasses were glasses for both eyes that used rectangular prisms (manufactured by Takei Kiki). These glasses reversed top and bottom of the image with the prisms and created a narrow field of vision (vertical 27°, horizontal 40°). For comparison in each experiment, glasses that restrict the visual field that were made by the researchers were used at the same time as the inversing prism glasses.

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Notes

1) Eccles, J.C.: the brain and the unity of conscious experience, Cambridge University Press, London, 1965.

2) Eccles, J.C.: The understanding of the brain, McGraw-Hill Book Co., New York, 1973.

3) Evert, P. H.: A study of the effect of inverted retinal stimulation upon co-ordination behavior, Genet. Psychol. Monogra. 7:177, 1930.

4) Gonshor, A. and Jones, G.M.: Extreme vestibulo-ocular adaptation induced by prolonged optical reversal of vision, J. Psysiol. 256: 381, 1976.

5) Gonshor, A. and Jones, G.M.: Short-term adaptive change in the human vestibulo-ocular reflex arch, J. Psysiol. 256: 361, 1976.

6) Harris, C.S.: Adaptation to displaced vision: Visual motor or proprioceptive change?, Science, 140:812, 1963.

7) Harris, C.S.: Perceptual adaptation to inverted, reversed, and displaced vision, Psychol. Rev. 72: 419, 1965.

8) Held, R. and Bossom, J.: Neonatal deprivation and adult rearrangement: Complementary techniques for analyzing plastic sensory-motor coordination, J. comp. psysiol. psychol. 54: 33, 1961.

9) Held, R.: Motor-sensory feedback and the geometry of visual space, Science, 141:722, 1963.

10) Held, R. and Hein, A.: Movement-produced stimulation in the development of visually guided behavior, J. comp. physiol. psychol., 56: 872, 1963.

11) Held, R.: Plasticity in sensory-motor systems, Sci. Amer., 213: 84, 1965.

12) Katori Hiroto, Chikaku - Undō Kyōō, Wada Yōhei, Ōyama Masao, Imai Shogo, eds.: Shinrigaku Handobukku (Psychology Handbook), 140, Seishin Shōbō, Tokyo, 1969.

13) Kachiki Yasutsugu: Kankaku no Chitsujo, Nō no Seirigaku (Sensory Learning and the physiology of the brain) Chapter 4, p. 168, Asakura Shoten, 1966.

14) Makino Tatsurō: Gyakutenshiya no Chikaku (Perception in an inverted visual field), Jinbun Kenkyū (Osaka University), 14: 157, 1963.

The tests that were conducted were as follows:

1) Cutting circles: circles 6cm in diameter that were drawn on small sheets of paper (14.5cm x 10.5cm) were cut out with scissors.

2) Copying words: the subjects wrote five words in phonetic characters (hiragana) and in Chinese characters (kanji).

3) Copying short and long sentences: short sentences of forteen characters in length and long sentences of 175 characters.

4) Copying figures: subjects drew a picture of a house.

5) Level of activity: the subjects strolled freely about the hospital in their free time. The distance that they walked each day was calculated by marking the route they walked on a rough plan of the hospital.

6) Subjective evaluation of feelings of strangeness because of the glasses: a) oscillation in the visual field; b) feelings about the reality of the outside world; c) feelings of dizziness after removing the glasses; these were given a rating of 0 to 5 every day.

Results

1) Cutting Circles (Figure 1)

The task of cutting out circles 6cm in diameter is usually done in one continuous motion while turning the paper. But using the scissors with the prism glasses is extremely difficult. First, it is a problem to bring the scissors to the right place on the paper. Next, to determine the direction to use the scissors

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15) Makino Tatsurō: Shikūkan no Teii to Shintaiundō (Movement and location in visual space), Ōyama Masao, ed., Shozashinrigaku 4 Chikaku, 191, Tokyo, 1976.

16) Makino Tatsurō: Sakasa no Sekai - Jiko to Gaikai (The inverted world -- the individual and the outside world), Tetsugakushi (Philosophical Magazine), 4:1, 1976.

17) Nakao Takehisa, et.al. : Gyakutenshiya e no Tekiō ni Kansuru Kenkyū - Kakushu Kensa ni yoru Kentō (Research related to adaptation to an inverted visual field -- an investigation of various tests), Kyushin Seii, 1980.

18) Nakamura Yujirō: Kyōtsūkankuron (A theory about integrated senses), Iwanami Shoten, Tokyo, 1980.

19) Peterson, J. and Peterson J.K.: Does practice with inverting lenses make vision normal? Psychol. Monogr. 16: 12, 1938.

20) Rock, I.: The nature of perceptual adaptation, Basic Books, New York, 1966.

21) Rock, I. and Harris C.S.: Vision and touch, Sci. Amer. 216:96,1967.

22) Shimojō Nobuho: Gyakushin - Hantenshiya Jikken ni tsuite no Ichikōsatsu (A study of experiments with inverted and reversed visual fields), Shinrigaku Hyōron (Psychology Review), 21:315, 1978.

23) Snyder, F.W. and Pronko, N.H.: Vision with spatial inversion, Univ. of Wichita Press, Wichita, 1952.

24) Stratton, G.: Some preliminary experiments on vision without inversion of the retinal image, Psychol. Rev. 3:611, 1896.

25) Stratton, G.M.: Vision without inversion of the retinal image, Psychol. Rev., 4:341, 1897a.

26) Stratton, G.M.: Vision without inversion of the retinal image, Psychol. Rev. 4:463, 1897b.

27) Welch, R.B.: Research on adaptation to rear-ranged vision, Perception, 3:367, 1974.

they moved the scissors over the paper, but with the visual guide they ended up confused. FIgure 1 shows the time required for this task. But, as shown by C, although it is a task that usually requires about 23 seconds, in the situation where the glasses were first put on it required more than 200 seconds and the circles were rough and irregular. (P: a test of both subjects before the experiment began.) On Day 1 after the subjects had gotten used to the glasses for several hours, the task took more than 100 seconds and the cut-outs were rough. But on Day 2 the time was reduced to about 50 seconds (comparatively two times normal) and they were able to cut in one motion without changing their grip on the scissors. After this, the time required gradually approached normal. This shows that for a task using scissors that is basically a comparatively simple case of hand-eye coordination like cutting circles, the subjects will become adapted and able to perform the task after wearing the glasses for one to two days.

2) Copying Words (Figure 2)

This test was conducted on Day 3 and Day 6. The subjects were asked to write the five hiragana (phonetic, cursive characters) and kanji (Chinese characters) words shown below Figure 2. These tasks usually require 16 and 27 seconds respectively, but on Day 2 the hiragana words took more than 100 seconds and more than 60 seconds on Day 6. The kanji words took more than 180 seconds on Day 3 and more than 130 seconds on Day 6. For the kanji task on Day 3, there was a great difference between the two subjects/266

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This seemed to be related to the attitude that the subjects had about copying.

In the case of copying, for hiragana and simple kanji a visual guide is not necessary to write the character. On the other hand, for complex characters, to correctly place the left and right sides of the character a visual guide is necessary. When the subjects tried to write hiragana or simple kanji accurately with a visual guide, the prism glasses ended up being a hinderance. For copying, the differences in the time required to copy the sentences by the subjects appears to result from a difference in attitude that depends on the visual guide.

3) Copying Short and Long Sentences

a) Copying Short Sentences (Figure 3)

Sentences of 14 characters that are a combination of Chinese characters and phonetic characters can usually be written in about 16 seconds. This test was conducted from Day 2 on. On Day 2 it required more than 120 seconds. This test showed the same difference between the subjects that was seen before in the word transcribing test. In short, subject E.U. required 50 seconds more time than M.T. did. However, this differences disappeared from Day 4 on. That is, until about Day 3 of the experiment differences in attitude between the subjects seemed to appear, but after than the differences disappeared. On Day 3 the time required decreased to a maximum of 30 seconds for both subjects, and it now took them only twice as much time as normal.

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b) Copying Long Sentences (Figure 4)

On the third day using the prism glasses, because we found that the subjects could do the copying fairly well, a test of copying sentences that were 175 characters long and that contained both Chinese characters and phonetic characters was administered from Day 3 on. The copying of these sentences can normally be completed in about 4 minutes 17 seconds, but on Day 3 it took more than 17 minutes. By Day 7 they were able to do it in about half the time, eight to nine minutes, but this was still twice as much time as normal.

4) Copying Figures (Figure 5)

The copying of a simple line drawing of a house can usually be done in less than 16 seconds. But when done with the prism glasses, the time averaged 288 seconds (N=17) and clearly the time increased. Also, the figure was poorly drawn. It took 50 seconds on the sixth day wearing the glasses, 40 seconds on the seventh day and by then the subjects were able to draw the figure smoothly. This was still two to three times the amount of time normally required. Figure 5 shows E.U.'s drawing before the experiment began and he had experienced the glasses, and also his drawing on Day 7. As can be seen from the figures, when not yet adjusted to the glasses, placing the pencil on the right point and moving it in the right direction take several unsteady attempts.

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5) Each Day's Level of Mobility (Figure 6)

As stated in the Methods section, the distance the subjects walked every day was calculated using a map based on the subjects' reports. C in Figure 6 shows the average distance that the subjects walked during the six days following the experiment. Generally, they walked 1500 meters daily. On Day 1 of the experiment the subjects were still not adapted to the glasses and activity was limited. They could barely leave the room to go to the toilet, and they walked feeling their way along the corridor. When they wore the glasses, not only were things seen upside down, but the visual field was narrow, and in order to see where they were going they had to tilt their heads very far forward. If they move their heads, the visual field shakes. The things that they are looking at are unstable. They can't judge distances. Because of this, movement is restricted. But because we told them to use their time actively doing such things as walking, watching t.v., or reading, the subjects tried to do these things.

On Day 1 the subjects could barely go to the gift shop to do some shopping, but the distance they walked increased as the days passed. On Day 5 the distance was up to about 2000 meters, and they even walked more than they usually did. When it reached this level, they had gotten used to walking in the hallways and on the stairs and could move about pretty freely. Because they could

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go to the place they wanted to, and because the feelings of being restricted decreased, they said that they could go anywhere that they wanted to. However, because the visual field is narrow, many times they had to be careful of things outside of their field of vision.

On Day 6 and Day 7 the amount of testing increased and they had little time for walking, so the distance that the subjects walked on those days decreased. On Day 7 we observed the subjects riding a bike on a course in the ward. They could soon manage it and could do such things as turn circles and ride with one hand easily.

6) Changes Over Time in Feelings of Strangeness (Figure 7)

As stated in the Methods section, the amount of oscillation in the visual field experienced while using the glasses, the loss of a sense of reality when looking at things, and the feelings of dizziness that occurred when the subjects took off the glasses temporarily for meals, baths, sleeping, and when taking tests, were judged subjectively. Figure 7 shows the ratings given daily throughout the experiment. The oscillation in the visual field and loss of a sense of reality rapidly decreased until Day 3 and Day 4 of the experiment, but continued somewhat until the last day of the experiment. On the other hand, the dizziness that occurred when the glasses were removed increased strongly. It did not simply increase, but the length of time that the dizziness lasted after taking off the glasses also increased. On Days 1

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and 2 it lasted for five or ten minutes after taking off the glasses, but by Days 5 and 6, even while removing the glasses, not only were they dizzy, but they experienced a loss of reality like that they had experienced when they first put on the glasses. The loss of reality and dizziness that occurred when they moved after they removed the glasses when the experiment was over were evaluated over time as shown in the graph. These feelings continued for three or four days and then returned to normal. This effect was especially strong for E.U. Because of this, the subject stated that during that period he couldn't drive a car. P on the graph shows the degree of dizziness and feelings of unreality when the subjects put on the glasses briefly when they came in one week and two weeks after the end of the experiment to let us make polygraph recordings. But there was little oscillation in the visual field and also only slight dizziness when they took off the glasses. This means that the adaptation to the glasses continues for one to two weeks.

Considerations

As was mentioned in the Considerations section in our previous publications,[17)18)] the issue of adapting to the inverted visual field is roughly divided as follows: 1) The visual field becomes upright.[14)15)24)25)26)] 2) There is no change in vision, but there is physical adaptation to the inverted visual field.[3)6)7)21)23)27)] The issue is being debated from these two sides.

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Concerning the latter physical adaptation theory, there are various opinions. Many theories have been put forward, such as a reordering of the senses to create unity between vision and movement,[18] rearrangement of perceptions of the body,[13] and the theory that emphasizes the role of a sense of location.[12] In any case, dealing actively with the inverted world will speed up learning.[8)9)10)11)19)29)21] Concerning a change in visual perception, in our previous papers from observations of change in subjects' activity and reports of the subjects' experiences we found that upright vision did not occur even temporarily during a week of wearing the prism glasses. Our findings contradict Stratton [26] and Makino.[14)16]

Among the research with inversing prism glasses, this report deals with the change over time in the visual-motor response, the amount of activity, and subjective evaluations of feelings of unease. When we analyze the results, for all the tests there are shortened performance times and improvement in performance of the tasks over time. For example, for circle cutting there was rapid improvement within two or three days and performance approached normal.

As touched on briefly before, the test scores of the two subjects that participated in this experiment show the same trend, but there were some differences. Overall, in the early part of the experiment E.U.'s scores were worse that M.T.'s.

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But that was only in the beginning. After three or four days, they were both at the same level. Figure 8 compares both subjects on three tests. These differences show differences in reaction to the sudden inversion of the visual field between the two subjects. Various factors may account for this. The authors, in a different experiment with 18 subjects, had the subjects write their own names while wearing the prism glasses and then write them with their eyes closed. The results were that when wearing the glasses the average time was 220.7 seconds (greatest, 485 seconds; least, 36 seconds), when the subjects' eyes were shut the average was 43.3 seconds (greatest, 64 seconds; least, 23 seconds). This shows that it is faster to write one's own name with the eyes shut, and of course it shows that with the glasses visual control in disturbed. Also, because the range of times varied greatly, individual differences in dealing with the effects caused by the glasses are shown to be great. Also, perhaps the subjects, when given this kind of task, will write according to their mental image instead of relying on a visual guide. Actually, there are many instances in the early stages where it was better to move according to a mental image than to use vision as a guide.

In addition, Figure 8 shows differences in adapting to the different tests. For simple tasks like circle cutting, it shows that subjects progress within a week to the point that they are no different from the control. But for copying sentences,

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they only reach the level of two times the control, and if copying only Chinese characters they improve to the point where they require four to five times the normal amount of time. Thus, the degree of difficulty of the test seems to be, for any test, the extent to which the subjects use the visual guide or not. No matter how long the experiment continues, the question remains whether the subjects can adjust completely or not.

According to the sujects' reports of their experiences, in the early stages of wearing the glasses, other than the visual field seeming upside down, the entire visual field was narrow and the things that they could see shook when they moved their heads. When they tried to look up or down, and when they tilted their heads in that direction the things that they could see disappeared from the visual field. To bring their objective into view was very difficult. At the same time, things seemed unfamiliar and unreal. The movement in the visual field and the sense of unreality are often considered from the point of view of a lack of normal, undisturbed perception.[15)18)] Because of these feelings of strangeness the subjects are always very tense, there is no time to be aware of small visual details, so they could not easily catch changes in people's expressions and so forth. The subjects got very tired when they had worn the glasses for a long time, their heads felt heavy, and dizziness also occurred. However, these feelings of unease were only

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severe for the first two to three days and decreased after that. When they had become adjusted to the glasses, by contrast, they began to feel strange when they took them off. This relationship was shown by the evaluations of their experiences and changes in their level of activity. Because feelings of unease occurred when they took the glasses off, as the last day of the experiment approached they preferred to wear the glasses.

When the one week experiment ended, the subjects were liberated from the heavy prism glasses, but again for two or three days they had feelings of strangeness. These were fairly mild, but it was similar to when they had first put on the glasses. After that their vision returned to normal, but when we later tried to test them with the glasses we found that they adapted very quickly.

The problem of adapting to the prism glasses is of course a sensory problem. In this experiment we offer data that makes suggestions about recognition of the outside world, perception, and motor learning. Also, the unease from dizziness that occurs when putting on the glasses can be seen as a problem of eye movement and the equilibrium function of the eyes, or as a brain function from the inner ear to the mid-brain and corebellum. 1)2)4)5)22) Moreover, when inverted vision is used as a stimulus, the individual response to that stimulus can be thought of as a measure to judge individual attitudes.

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Summary

Experiments were carried out using inversing prism glasses for one week with two adult male subjects. The results of various sensory-motor tests, measurements of the level of activity, and subjective evaluations of the subjects' experiences were reported.

For sensory-motor tests such as circle cutting, copying sentences and copying figures, these could be accomplished fairly well by Day 3 and Day 4 of the experiment. This was related to the degree of difficulty of the task. Circle cutting could be done almost as well as the control. For copying sentences, the subjects adapted to the extent that they could do it in two to three times the time required by the control. In the one week experiment, even temporary upright vision was not seen. According to the subjects' accounts of their experiences, they said that they could move about freely and it did not matter whether vision was right side up or upside down.

The oscillation in the visual field and the lessening of feelings of reality were created by the prism glasses but when they continued to wear them, a feeling of unease and temporary dizziness occurred when they took them off. When we had the subjects make subjective evaluations of these experiences, they said that the oscillation in the visual field and the loss of a sense of reality lessened as the days passed, but at the same time the feelings of uneasiness when they took off the glasses got stronger.

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and they found that there was this inverse relationship. Also, after the one week experiment ended, the feelings of uneasiness continued for two to three days and this seemed much like when they had first worn the prism glasses. By measuring the subjects' level of activity, we found that along with the subjects' adaptation to the glasses, the distance they walked increased.

Differences in the degree of adaptation to the prism glasses could be seen between the two subjects. This can be thought of as reflecting differences in attitude related to individual methods for solving the problems created by the inverted visual field.

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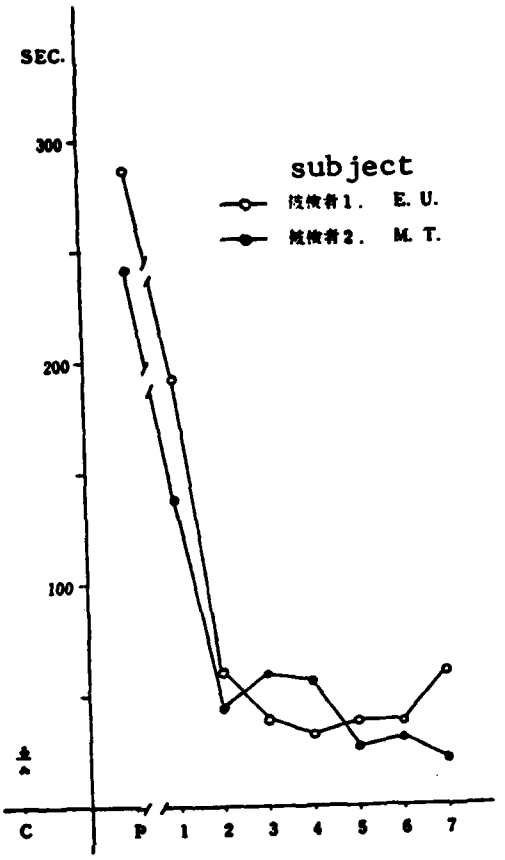

Figure 1: Circle Cutting: C is the control, P is the result at the beginning of the experiment. The vertical axis shows the time required, the horizontal shows the day the test was done.

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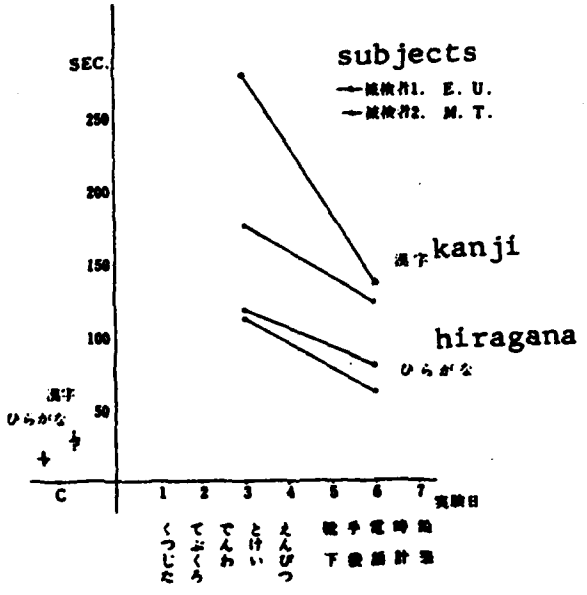

Figure 2: Copying Words. This was a test of kanji (Chinese characters) and hiragana (phonetic characters). The words used are shown below the graph.

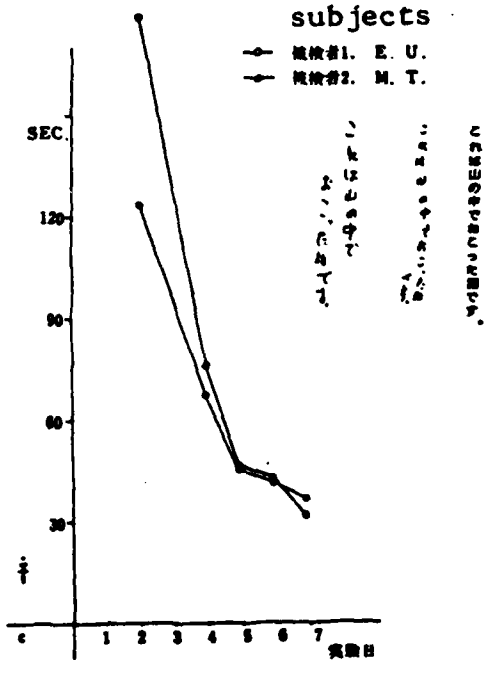

Figure 3: Copying Short Sentences. Next to sample are shown E.U.'s sentences for Day 2(center), and Day 7 (left).

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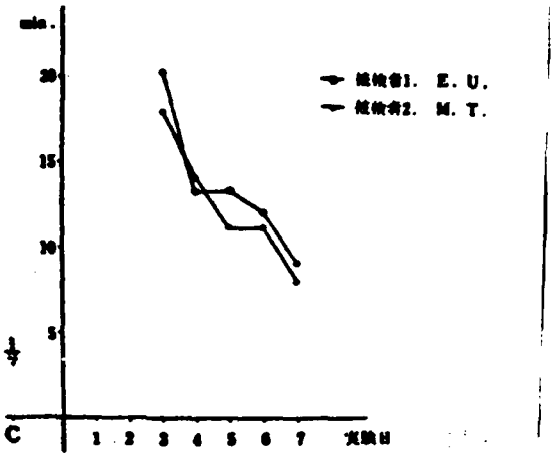

Figure 4: Copying Long Sentences.

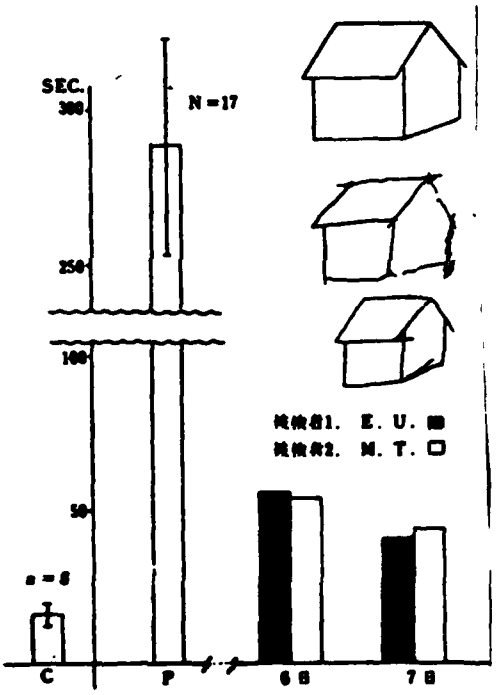

Figure 5: Copying Figures. C is the control (n=8), P was at the time they first put on the glasses (n=17). The center figure was the right was drawn by E.U. at P, the bottom on Day 7.

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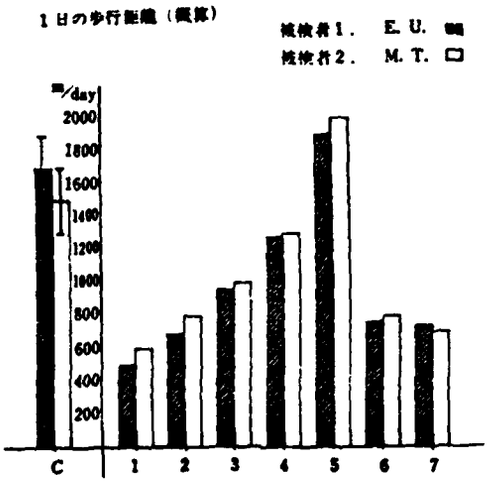

Figure 6: Distance Walked Each Day. C shows an average daily distance for the subjects calculated over a six day period.

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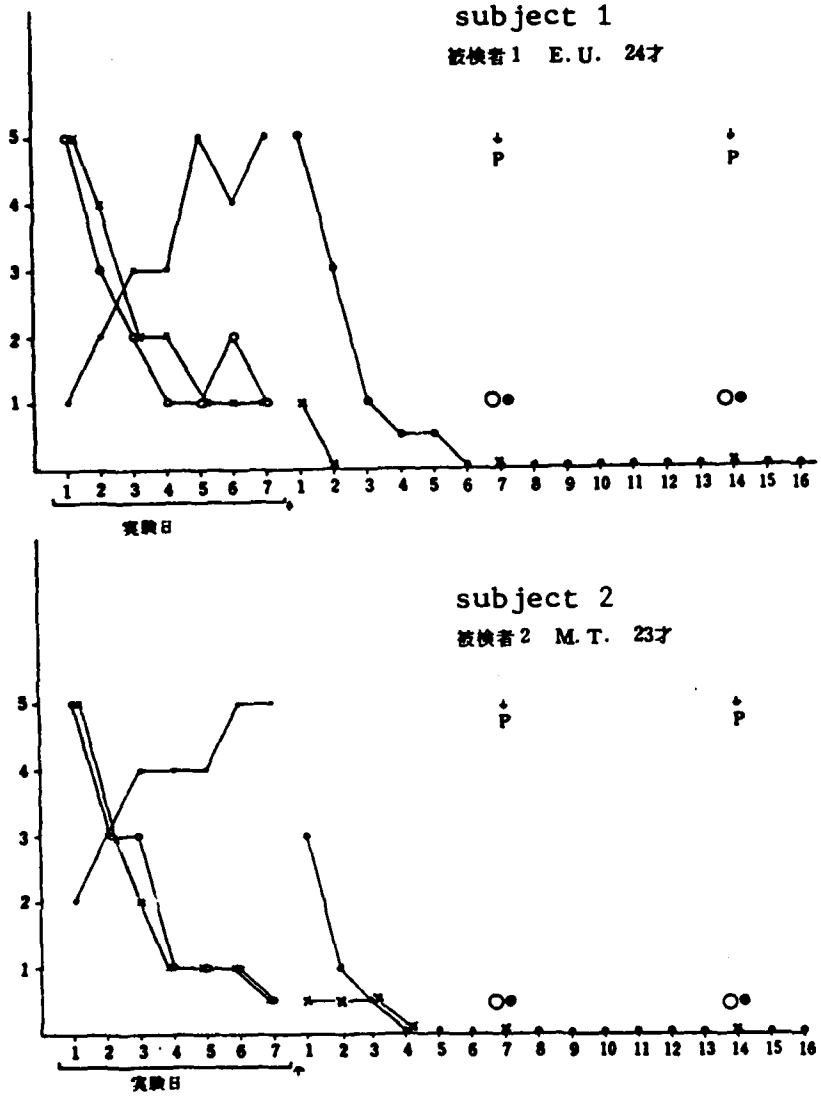

Figure 7: Subjective Ratings of Feelings of Unease. · indicates feelings of dizziness when glasses were removed. ○ indicates oscillation in the visual field at the time the glasses are put on. x indicates feelings of unreality when wearing glasses. After experiment, ● indicates periodically occurring dizziness, ○ feelings of unreality. P are times subjects came in to take polygraph tests.

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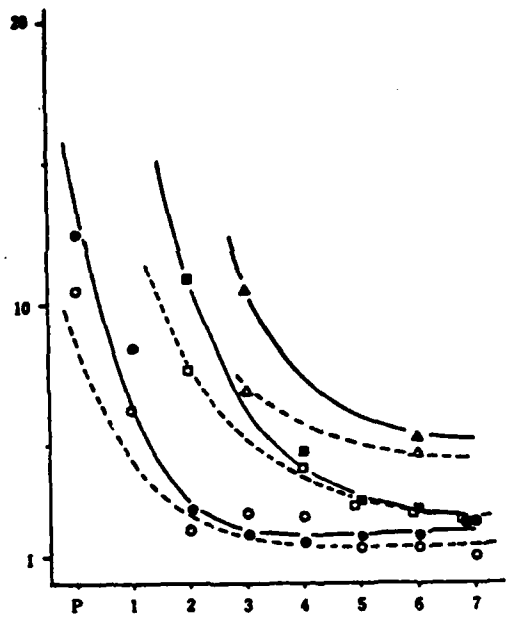

Figure 8: Shows the results for both subjects on three tasks compared to the control. Circle cutting (circles), copying Chinese characters (triangles), and copying short sentences (squares). Black is E.U., white is M.T. The vertical axis gives the subjects' times in comparison to the control (for example, two times the control). P is when they had first put on the glasses.

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Notes

1) Eccles, J.C.: the brain and the unity of conscious experience, Cambridge University Press, London, 1965.

2) Eccles, J.C.: The understanding of the brain, McGraw-Hill Book Co., New York, 1973.

3) Evert, P. H.: A study of the effect of inverted retinal stimulation upon co-ordination behavior, Genet. Psychol. Monogra. 7:177, 1930.

4) Gonshor, A. and Jones, G.M.: Extreme vestibulo-ocular adaptation induced by prolonged optical reversal of vision, J. Psysiol. 256: 381, 1976.

5) Gonshor, A. and Jones, G.M.: Short-term adaptive change in the human vestibulo-ocular reflex arch, J. Psysiol. 256: 361, 1976.

6) Harris, C.S.: Adaptation to displaced vision: Visual motor or proprioceptive change?, Science, 140:812, 1963.

7) Harris, C.S.: Perceptual adaptation to inverted, reversed, and displaced vision, Psychol. Rev. 72: 419, 1965.

8) Held, R. and Bossom, J.: Neonatal deprivation and adult rearrangement: Complementary techniques for analyzing plastic sensory-motor coordination, J. comp. psysiol. psychol. 54: 33, 1961.

9) Held, R.: Motor-sensory feedback and the geometry of visual space, Science, 141:722, 1963.

10) Held, R. and Hein, A.: Movement-produced stimulation in the development of visually guided behavior, J. comp. physiol. psychol., 56: 872, 1963.

11) Held, R.: Plasticity in sensory-motor systems, Sci. Amer., 213: 84, 1965.

12) Katori Hiroto, Chikaku - Undō Kyōō, Wada Yōhei, Ōyama Masao, Imai Shogo, eds.: Shinrigaku Handobukku (Psychology Handbook), 140, Seishin Shōbō, Tokyo, 1969.

13) Kachiki Yasutsugu: Kankaku no Chitsujo, Nō no Seirigaku (Sensory Learning and the physiology of the brain) Chapter 4, p. 168, Asakura Shoten, 1966.

14) Makino Tatsurō: Gyakutenshiya no Chikaku (Perception in an inverted visual field), Jinbun Kenkyū (Osaka University), 14: 157, 1963.

15) Makino Tatsurō: Shikūkan no Teii to Shintaiundō (Movement and location in visual space), Ōyama Masao, ed., Shozashinrigaku 4 Chikaku, 191, Tokyo, 1976.

16) Makino Tatsurō: Sakasa no Sekai - Jiko to Gaikai (The inverted world -- the individual and the outside world), Tetsugakushi (Philosophical Magazine), 4:1, 1976.

17) Nakao Takehisa, et.al. : Gyakutenshiya e no Tekiō ni Kansuru Kenkyū - Kakushu Kensa ni yoru Kentō (Research related to adaptation to an inverted visual field -- an investigation of various tests), Kyushin Seii, 1980.

18) Nakamura Yujirō: Kyōtsūkankuron (A theory about integrated senses), Iwanami Shoten, Tokyo, 1980.

19) Peterson, J. and Peterson J.K.: Does practice with inverting lenses make vision normal? Psychol. Monogr. 16: 12, 1938.

20) Rock, I.: The nature of perceptual adaptation, Basic Books, New York, 1966.

21) Rock, I. and Harris C.S.: Vision and touch, Sci. Amer. 216:96,1967.

22) Shimojō Nobuho: Gyakushin - Hantenshiya Jikken ni tsuite no Ichikōsatsu (A study of experiments with inverted and reversed visual fields), Shinrigaku Hyōron (Psychology Review), 21:315, 1978.

23) Snyder, F.W. and Pronko, N.H.: Vision with spatial inversion, Univ. of Wichita Press, Wichita, 1952.

24) Stratton, G.: Some preliminary experiments on vision without inversion of the retinal image, Psychol. Rev. 3:611, 1896.

25) Stratton, G.M.: Vision without inversion of the retinal image, Psychol. Rev., 4:341, 1897a.

26) Stratton, G.M.: Vision without inversion of the retinal image, Psychol. Rev. 4:463, 1897b.

27) Welch, R.B.: Research on adaptation to rear-ranged vision, Perception, 3:367, 1974.

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